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BULLETIN NO. 2

ON THE

PHOSPHATES AND MARLS

OF

ALABAMA.

BY

EUGENE ALLEN SMITH,

STATE GEOLOGIST.

MONTGOMERY, ALA.:
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PREFACE.

In the summer of 1883 the systematic examination of the Cretaceous and Tertiary formations of Alabama was taken up by the Geological Survey.

The first work was done in the vicinity of the Alabama and Tombigbee rivers by Mr. L. C. Johnson and myself, and later by Mr. D. W. Langdon and myself. The results of this study was a preliminary report on this region published as Bulletin No. 43, of the United States Geological Survey.

Since 1887 the examination has been carried eastward to the Chattahoochee river chiefly by Mr. Langdon, and a report upon the Cretaceous and Tertiary formations of the whole State is now in great part in manuscript and will be published as soon as the map, which is to illustrate it, can be made ready.

Enquiries are continually being made concerning the natural fertilizers of the State, and in view of the interest in these matters thus shown, it has been thought desirable to publish so much of the report above referred to as relates to the phosphates and marls of Alabama as a Bulletin in advance of the rest.

EUGENE A. SMITH.

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THE PHOSPHATES OF ALABAMA.

HISTORICAL.

In the early part of the spring of 1884 I received from Mr. J. W. Spencer, of Hamburg, Perry county, a box of phosphatic nodules and shell casts. Mr. Spencer's attention had been directed to these things which occurred on his land, by some published description of the South Carolina phosphates. He had sent specimens to Dr. C. U. Shepard, of Charleston, S. C., who had analyzed them, and, on recognizing them as phosphates, had sent his assistant, Dr. Chazal, to Alabama to investigate the occurrence. Dr. Chazal examined the ground and came to the conclusion that the phosphates were not in sufficient quantity to be of commercial value, and this conclusion seems to be borne out by our subsequent investigations, so far as the *high grade* phosphates are concerned, and these were all that Dr. Chazal particularly examined.

In April 1884, I went to Hamburg personally to see the mode of occurrence of the phosphates, and finding in addition to the nodular phosphates, a phosphatic greensand, and being satisfied that the latter at least, would become an article of great value to our agricultural interests, I announced the fact through the papers, and sent Mr. D. W. Langdon, Jr. Assistant in the State Geological Survey, to examine the occurrences about Hamburg more closely, and to follow the outcrop of these deposits from Hamburg east and west across the state.

Soon after my announcement, Prof. Stubbs of Auburn, and his Assistant, Prof. Leroy Broun, Jr., came also to Hamburg and the last named gentleman was with Mr. Langdon in his subsequent investigations about Hamburg.

Afterwards, Mr. Broun went into Macon, Russell, and Barbour counties, where he also found the phosphates.

Mr. Langdon traced the Hamburg deposits across to Eutaw, and eastward to near Selma. I sent Mr. John Daniel of this University down to Summerfield, and afterwards to east Dallas and western Autauga, and later still, into the southern part of Dallas county, where he collected for the survey some valuable notes of the occurrence in those localities.

Having indicated in the newspapers, several places at which I thought the phosphates likely to be found, I received, from persons all along this line of probable outcrop, specimens which in most cases proved to be phosphatic.

Thus in a very short time, it was known that the Hamburg belt of phosphates extended from the Mississippi line through Pickens, Greene, Hale, Dallas, Autauga, and Elmore counties, while Prof. Broun's examinations showed them to exist in Macon and Russell.

A systematic examination of the specimens in the collection of the Geological Survey in the cabinet of the University, soon revealed the fact that the limestones and other rocks of the Ripley group of the Cretaceous formation, immediately *overlying* the Rotten Limestone, were in places more or less phosphatic. This was announced in the newspapers, and a list published of the localities where the phosphates were likely to occur, and in a short time specimens were sent up to the University from many localities, showing that the phosphates were very generally present along this belt also across the entire state. Examinations were made by Mr. John Daniel, Mr. Langdon and myself of these deposits in Dallas, Wilcox, Marengo, and Sumter counties as to their mode of occurrence and the thickness of the beds.

During the summer of 1884 Mr. Langdon, while collecting for Mr. T. H. Aldrich in the southern part of the state, discovered that there were phosphatic materials occurring still further south and in the Tertiary formation, the previously discovered beds being in the Cretaceous.

In the spring and early summer 1884, many analyses of phosphates were made at the University of Alabama, and later in the summer I sent the specimens collected by me, either through my assistants or through correspondents, over to

Auburn where they were analyzed in the state laboratory of the A. & M. College under the supervision of Prof. Stubbs. The results of these analyses were published in Bulletin No. 5, of the Agricultural Department, with a joint report on the phosphates of Alabama, by Prof. Stubbs and myself.

The specimens analyzed were all contributed by the Geological Survey, except about twenty, which were furnished by Prof. Broun from the eastern counties of the State. The specimens from Hamburg analyzed at the State laboratory were collected by Messrs. Broun and Langdon. The arrangement of the material in this Bulletin No. 5. is such that it is very difficult to make any practical use of the analyses, and a reprint of the same will not be amiss.

Soon after the first announcement of the discovery of the phosphates, hopes of making sudden fortunes were raised in the minds of many of our citizens, but when after further investigation, it seemed improbable that high grade phosphates suitable for exportation would be found in Alabama in commercial quantity, there came a reaction and doubts have arisen as to whether our phosphates are worth anything at all. With the example of New Jersey before us, there should be no possibility of a doubt as to the future of agriculture in Alabama.

If we compare the two states, New Jersey and South Carolina, one of which has only low grade phosphates suitable for use at home but not rich enough for export, the other with high grade phosphates which are shipped to all parts of the world, we can hardly fail to see that the advantage to the state at large is in favor of New Jersey with its low grade marls. In South Carolina the phosphates are either exported or manufactured into high grade fertilizers from which, in all probability, the soils of that state derive no more benefit than the soils of other states. The marls of New Jersey on the other hand are used almost exclusively upon the soils of that state, and the result of twenty-five years application of them has been to cause the lands of New Jersey to be worth more per acre than those of any other state.

With an abundance of high grade phosphate only, in this state, it is probable that our experience would not be different from that of the people of South Carolina; our soils would as a rule be no better for it, since the greater part would undoubtedly be exported to enrich the soils of some other country.

On the whole it seems to me to be a matter for congratulation rather than otherwise that the most abundant phosphates of Alabama are of a nature which will probably keep them at home. If they are used rationally by our people, there can be no doubt that the enhancement in the value of lands and the increase in the crops due to their use, will represent a larger amount of capital than would the trade in exported rock. And even if the sums realized by exportation were greater the money would be in fewer hands, and therefore accomplish less general good.

It is discouraging that our people as a rule are so slow in taking advantage of the natural fertilizers of the state.

This is however, in great measure due to lack of information on the subject; and as comparatively little printed matter comes under the notice of the majority of our farmers they can never be induced by any amount of writing to take up these things which lie at their very door.

It is only by the example of the best posted, and most successful farmers of each neighborhood, who are willing to experiment with these fertilizers, and show practically their value, that the great mass of the farmers will ever be brought to use them. Fortunately, in several parts of the state, there are farmers who have made practical field tests of these marls, and from these as a center, the infection will spread it is to be hoped, over the whole state.

GEOLOGICAL AGE, MODE OF OCCURRENCE, AND COMPOSITION OF THE PHOSPHATES.

Phosphatic marls have been found in Alabama both in the Cretaceous and Tertiary formations, and for our present purposes they can be most conveniently considered in their geological relations.

From the margin of the area occupied by the rocks of the older formations of this state, the strata of the Cretaceous and Tertiary formations, make up the whole mass of the land southward to the gulf of Mexico. The margin of these older rocks, which is at the same time the inner or upper margin of the lowest of the Cretaceous formations, stretches in a curve from the north-western corner of the state across near Fayette Court House, Tuscaloosa, Centerville, and Wetumpka, to Columbus, Georgia. All the Cretaceous and Tertiary beds have a gentle slope or dip towards the gulf of 25 to 40 feet to the mile, and they occupy the surface across the state in approximately parallel belts, the oldest beds furthest north, and the newer further towards the south in the order of their relative ages. As a further consequence of this dip of the strata, each one of these beds, while appearing at the surface only in a comparatively narrow belt, passes beneath the newer beds, and may be found below the surface at depths constantly increasing as we go southward.

The geographical distribution of the surface outcrops of the several divisions of the Cretaceous and Tertiary may be seen by reference to the map accompanying my Agricultural Report for the years 1881-2. But since that report will probably be acessible to very few, I shall preface the detailed descriptions of the marls, by a short account of each of the formations in which they occur:

CRETACEOUS FORMATION.

General Characters.

This formation is made up of some 2600 to 3500 feet in thickness of strata, which are sands, clays, and limestones in many alternations. The subdivisions of the formation are four in number, which in ascending order are as follows:

1. THE TUSCALOOSA.—This, the lowermost of the Cretaceous series, consists in the main of sands and clays aggregating,

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by estimate, 1000 feet in thickness. The sands are usually light colored and cross-bedded; the clays are in part laminated in which case they often hold well preserved leaves and other remains of plants and occasionally small beds of lignite; and in part massive when they are of dark red and purple colors on the outcrop, where exposed to the air, but usually of dark gray color where fresh and protected from the action of the weather. The clays of this formation are quite similar both in composition and in their geological relations, to the clays of New Jersey, and are gradually being utlized in this state in the manufacture of fire-brick, pottery, etc. All the materials and the fossils of the Tuscaloosa formation, and the numerous beds of pebbles, as well as the cross-bedded sands, testify to the existence of currents when the beds were deposited.

2. THE EUTAW.—Next above the strata of the Tuscaloosa come those of the Eutaw, which, like the former, are in the main composed of sands and clays, but which, unlike the Tuscaloosa beds, often hold grains of the mineral known as *greensand* or *glauconite*, essentially a compound of silica, iron and potassium, and generally considered of marine origin. The greensand beds, upon exposure to the air, gradually assume a yellowish brown or reddish color due to the oxidation of the iron of the greensand.

The Eutaw beds in places hold also marine shells, usually much decomposed and difficult of identification, but still proof of their marine origin. Other beds of the Eutaw series on the contrary are filled with leaf impressions and other fossils of vegetable origin, in which they resemble the underlying Tuscaloosa beds. The thickness of the Eutaw may be put at about 300 feet.

3. THE ROTTEN LIMESTONE OR CHALK.—Overlying the Eutaw there is a great thickness,up to 1000 feet,of calcareous strata, prevalently a clayey limestone or indurated marl, but with admixtures of clay beds and of beds of true chalk (a soft friable limestone consisting almost entirely of microscopic shells, similar to those which are at present found only in the deeper parts of the sea). At the base of this calcareous

formation, as well as at its summit, there are transition beds more or less sandy, grading on the one hand into the Eutaw beds below, and on the other hand into the Ripley beds above. It is in these transition beds that the phosphates occur, and to them we shall accordingly direct special attention in the sequel. While the Tuscaloosa and Eutaw divisions continue across the State with tolerably constant characters, the chalk thins out to the eastward and has not been identified eastward of Macon and Bullock Counties.

4. THE RIPLEY.—Next above the Rotten Limestone, and forming the uppermost member of the Cretaceous formation, lie the beds of the Ripley series, so named from their characteristic occurrence near the town of Ripley in Mississippi. These consist of hard sandy crystalline limestones near the base of the series and calcareous clays and bluish micaceous, sandy marls above. The alternation of harder and softer beds gives character to the topography of the country in which these rocks occur, and which in western Alabama is known as the "hill prairie" country.

The prairie hills are usually very steep and abrupt, and the depressions between them are filled in with the sandy loams of the LaFayette* formation, usually more or less mingled with the washings of the calcareous clays which alternate with the hard limestone ledges of the hillsides. The soils resulting from these mixtures are stiff, marly, and in many cases extremely fertile. Towards the eastern part of the state the bluish, sandy, micaceous marls become more prevalent and attain a very great thickness, and occupy the surface over a belt nearly 100 miles in width. The well known farming lands of the Cowikee Creek and Bear Creek in Russell and Barbour counties are based upon these blue marls. The thickness of the Ripley varies between wide limits, being perhaps 500 feet as a maximum in west Alabama, and increasing to much more than 1,000 feet in east

---

*This is the name given to that mantle of red loam and pebbles which overspreads the greater part of the southern half of Alabama, in many cases hiding more or less completely the older rocks of the country. This formation has heretofore been described under the names of "Drift" and "Orange Sand."

Alabama, where the Rotten Limestone seems to be entirely wanting.

Phosphatic Deposits of the Cretaceous.

As before stated, the phosphatic deposits of our Cretaceous formations occur mainly in two positions, viz: At the base and at the summit of the Rotten Limestone; in both cases in transition beds between this and the underlying and overlying rocks. The Rotten Limestone being, as above noted, a calcareous clayey formation in great part, yields upon disintegration soils that are for the most part strongly limy, and colored dark and sometimes nearly black with vegetable matter. The region formed by the Rotten Limestone is commonly known throughout this state under the names "Black Belt," "Canebrake," "Black prairies," in allusion to prominent characteristics. The positions of the two areas in which the most important of the phosphatic deposits are to be looked for are easily located; the one occurs along the northern border of the prairie belt, and the other along its southern border, in both cases where the transition from the lime lands to the sandy lands is found. The phosphate belt to the north of the prairies we have named the *Eutaw, Hamburg, Selma Belt;* the one to the south of the prairies is known as *Livingston, Fort Deposit, Union Springs Belt.* In the special descriptions of these occurrences it will be best to consider them separately.

1. THE EUTAW, HAMBURG, SELMA BELT.

HAMBURG.

Mr. J. W. Spencer appears to have been the first to suspect the true character of the phosphatic nodules which are so abundant about the old town of Hamburg in Perry county. After analyses made by Dr. C. U. Shepard, of Charleston, S. C., and in the laboratory of the Alabama Geological Survey at Tuscaloosa, had placed beyond doubt the composition of these nodules, the locality was visited and closely examined by a number of persons, but particularly by Mr. D. W. Langdon, Jr., of the Geological Survey, and Mr. W. Leroy Broun, Jr., Assistant Chemist of the A. & M. College.

The following section of the strata at Hamburg, given in descending order, will show the mode of occurrence and general character of the phosphatic materials at that place:

Section at Hamburg.

1. Base of the Rotten Limestone. The beds here included contain very little phosphoric acid.

2. Greensand, averaging about five feet in thickness, and strongly impregnated with phosphoric acid. The lowermost strata of this greensand contain a few phosphatic nodules, which, however, become much more abundant in the next succeeding stratum.

3. Sandy calcareous stratum, matrix of the nodules, five to six feet in thickness. Where this bed outcrops in the fields the surface of the ground is covered with the phosphatic nodules, which are concretionary masses of nearly pure phosphate of lime, of exceedingly irregular shapes, and from sizes varying from small pebbles no larger than a pea to pieces two or more inches in diameter. The nodules vary also in color, from light gray to dark brown, and they may easily be recognized by the peculiar odor which they emit when rubbed together or broken. This odor is described by some as "fishy," by others as "bituminous" or "naphthous," as it resembles to some degree the odor of crude petroleum. Along with these phosphatic nodules are also great numbers of casts or moulds of fossils, usually somewhat worn, and badly preserved, and consisting of fragments of ammonites, baculites, nautili, and other well known Cretaceous forms. These casts have themselves, in most cases, been more or less phosphatized, and in some instances have almost entirely lost their original shape and structure, and are then difficult to distinguish from the nodules. Besides these there are great numbers of the teeth of sharks and bones of saurians.

The nodules are found as above stated, in small numbers in the lower beds of the greensand, but more abundantly in the next underlying stratum, mainly through about two to two and a half feet of its thickness. In quantity, according to the estimates of Messrs. Langdon and Broun, these nodules would average some two to eight hundred tons to the acre. The nodules compare favorably in composition with those of South Carolina, as may be seen from the analyses given below.

4. Hard ledge of calcareous sand, six to eight inches in thickness, and holding a considerable quantity of phosphoric acid as shown by the subjoined analyses.

5. Loose sandy beds, micaceous, with numbers of sharks' teeth and in the upper part just beneath the hard ledge No. 4, filled with the shells of small oysters. This division is about thirty feet thick, and holds some phosphoric acid as may be seen from the analyses.

6. Compact laminated sands consisting of white-quartz grains mixed with grains of greensand, 15 feet.

7. Compact blue sands with greensand, 8 to 10 feet.

Beds Nos. 6 and 7, as well as part of No. 5, are well exhibited in a bluff just below Mr. Spencer's house, and east of the road.

The following (page 21) will show the composition (or rather the contents of phosphoric acid) of the various materials occurring at Hamburg:

a. The Nodules and Phosphatic Casts of Fossils from Spencer's Field, Hamburg.—The nodules and phosphatic casts which cover the ground in some parts of Mr. Spencer's field, have evidently come from the disintegration of bed No. 3 above, and represent the accumulation of years. In order to ascertain the proportion of these phosphates in the original rock, Mr. Langdon, at my suggestion, had four pits dug into No. 3 at different places, and collected and weighed the nodules occurring in a measured quantity of the earth from different depths in these pits, and from this he estimated the amount per acre of the phosphates which this bed would yield. His average of several such estimates is 377.92 tons to the acre, the nodules being distributed through 4 to 6 feet thickness of the matrix rock. It is doubtful if it would pay to extract these from the rock, but where they have already been weathered out and lie upon the surface, there would be no trouble in raking them up, and the amount which could thus be gathered is very considerable.

The Table on p. 21 will show the composition of the higher grade materials from Spencer's Field.

Analyses of Phosphatic Nodules and Shell Casts, Spencer's Field, Hamburg.

	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYST.
1. Surface Nodules (selected)	....	38.00	82.84	....	John Daniel, Univ'ty of Ala.
2. " "	....	35.5	77.39	....	" " "
3. Surface nodules, sample of 1 lb	....	25.66	55.88	......	Chas. Gibson, Chicago.
4. Nodule	....	22.02	48.00	....	W. I. Herzberg, Univ. of Ala.
5. Phosphatized shell	....	19.80	43.16	....	" " "
6. Surface nodules	1.09	26.13	57.04	....	Laboratory A. & M. College.
7. Black nodules	2.50	24.16	52.03	....	" " "
8. White nodules	21.94	20.07	43.81	....	" " "
9. Mixed nodules	9.79	19.97	43.59	....	" " "
10. Nodules from Pit No. 1	22.07	14 02	30.60	39.03	" " "

b. Matrix of the Nodules, Spencer's Field, Hamburg.—It may be seen from the section (page 17) that the nodules are imbedded in a stratum some five or six feet thick. The material of this matrix is sandy and calcareous, and it is strongly phosphatic, as may be seen from the analyses following, (page 23). It would undoubtedly be a good fertilizer:

Analyses of the Matrix of the Nodules, Spencer's Field, Hamburg.

	Insol'ble Matter.	Phos-phoric Acid.	Bone Phos-phate.	Lime.	ANALYST.
11. Matrix of nodules	......	4.2	9 16	....	John Daniel, Univ'ty of Ala.
12. Blue matrix of nodules	......	2.2	4.80	....	Chas. Gibson, Chicago, Ill..
13. White matrix of nodules	....	3.6	7.85	....	" "
14. Matrix rock, from Pit No. 1	30.28	2.58	5.63	30.06	Laboratory A. & M. College.
15. " " 3	32.50	3.85	8.40	29.61	" " "
16. " " 1	40 61	2.45	5.34	27.07	" " "
17. Matrix rock, 6 feet below surface, Pit No. 3	53 74	2.79	6.09	17.20	" " "
18. " 5 feet 9 in. below surface, Pit No. 1	33.81	2.26	4.93	27.85	" " "
19. " 20 in. below surface, " 2	47.13	1.46	3.18	24.41	" " "
20. " 9½ in. below surface, " 2	27.82	.95	2.09	41.00	" " "
21. " 21 in. below surface, " 2	31.55	3.58	7 81	32 07	" " "
22. Rock overlying matrix rock	35.17	2.20	4.80	24.10	" " "

c. The Greensand, Spencer's Field, Hamburg.—This bed is some five feet in thickness, and is throughout rather strongly impregnated with phosphoric acid. In some parts of the field, where exposed, this substance is indurated into a pretty firm rock, but in other places it is friable and incoherent, and occasionally it forms the suface soil which is cultivated. The analyses show a considerable variation in the percentage of phosphoric acid, the indurated rock containing the largest proportion, the loose rock next, and the soil least. Some of the analyses made from picked specimens of the hard greensand rock, show as much as 10 per cent phosphoric acid, but as the average is a good deal lower than this, I have inserted in the table (page 25) only such analyses as appear to represent the general average per cent of the phosphoric acid. The greensand taken from the pits dug by Mr. Langdon, show less phosphoric acid than the samples taken from the surface.

Analyses of Greensands—Spencer's Field, Hamburg, Perry County.

	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYST.
23. Indurated, greensand	....	9.00	19 62	......	John Daniel, Univ'ty of Ala.
24. " "	....	5.16	11.26	....	C. R. Westcott, " "
25. " "	....	8.12	17.70	....	Eugene A. Smith " "
26. " "	......	7.60	16 59	....	Chas. Gibson, Chicago.
27. Greensand, first 12 in. Pit No. 1	42 66	1.61	3.51	16.18	Laboratory A. & M. College.
28. " 9 in. below 27 "	34.52	2.79	6.09	13.86	" " "
29. " 7 in. below 28 "	31.55	2.13	4.65	9.14	" " "
30. " 20 in. below 29 "	......	3.38	7.37	8.40	" " "
31. Greensand forming soil, cultivated	41.42	.67	1.46	29.62	" " "
32. " " " "	41.11	.85	1.85	17.68	" " "
33. " " " "	48.81	4 35	9.56	9.13	" " "
34. " " " "	28.62	.66	1.44	24.80	" " "
35. White nodules found in greensand	3.91	3.85	8.40	49.83	" " "
37. Indurated greensand	....	4.80	10.26	....	D. W. Langdon, Jr., U. of A.
38. " "	....	5.90	12.86	....	" "

In order to ascertain whether or not it would be possible to concentrate the phosphatic material or the greensand grains of this stratum, Mr. Langdon made some experiments with the indurated greensand, loosely pulverizing it, subjecting it to strong mechanical agitation, then separating the upper half from the lower, and analyzing each as to its content of phosphoric acid and potash. Another experiment was made by stirring the pulverized greensand in water, allowing to settle and then determining the phosphoric acid and potash of the upper and lower halves as before. In neither case was any very marked result obtained, but there seems to be good reason for thinking that by some such mechanical process, it will be possible to concentrate the phosphate so as to render it suitable for shipment.

d. Sands and other strata underlying the nodule-bearing bed at Spencer's, near Hamburg.—Samples were taken of the materials underlying the nodule bed, at intervals of three feet, for some eighteen to twenty feet, and also of the indurated ledge between the nodule bed and the sands. All these contain phosphoric acid in considerably larger proportions than is commonly found in soils.

The subjoined analyses (page 27) show the phosphoric acid in the different parts of the Hamburg strata:

Analyses of the Strata Underlying the Nodule Bed—Spencer's, Hamburg.

	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYST.
39. First three feet below surface, Spencer's house.........	31.53	3.38	7.37	26.73	Laboratory A. & M. College.
40. Three feet below 39..............................	56.65	.69	1.50	21.20	" " "
41. Indurated ledge..................................	53.77	1.16	2.53	23.33	" " "
42. Two feet below ledge No. 41........................	92.30	.33	.72	9.47	" " "
43. Sands 3 feet below 42	91.89	.29	.63	2.85	" " "
44. Sands 3 feet below 43.............................	95.55	.44	.96	.72	" " "
45. Sands 3 feet below 44.............................	96.27	.12	.25	.75	" " "
46. Sands 3 feet below 45.............................	92.14	.39	.85	.69	" " "
47. Feruginous sand below King's Mill..................	91.40	.43	.92	.79	" " "
48. Lowest formation at King's Mill....................	90.42	.25	.54	.50	" " "

No. 39 is evidently a part of the nodule-bearing stratum of which several analyses have been given in a preceding table (page 23).

NEAR CAHABA RIVER.

From Hamburg, Messrs. Langdon and Broun followed the phosphatic formation eastward to the Cahaba River, where the following geological section was observed by them:

Section near Cahaba River, on land of Messrs. A. F. and A. J. Davis:

1. Rotten Limestone, increasing in depth southward.
2. Greensand marl, 5 to 6 feet thick.
3. Soft cream-colored rock, phosphatic, and bearing some nodules, and passing below into a grayish limestone holding the nodules, 4 to 6 feet.
4. Indurated calcareous sandy ledge, 1 to 1½ feet.
5. Yellow micaceous sand, the upper part holding shells; 30 feet.
6. Dark red sand containing more greensand than No. 5, the red color due probably to oxidation of greensand, 15 feet.
7. Indurated ledge similar to No. 4, but more variable in thickness, 6–12 inches.
8. Whitish sand with few grains of greensand, 10 inches.
9. Blue joint clay varying from 8 inches to 4 feet in thickness.
10. Red or orange colored sands similar to No. 6, 10 feet.
11. Greensand, four feet exposed above the water level in Cahaba river.

WEST OF HAMBURG.

Westward from Hamburg, Mr. Langdon traced the greensand and accompanying nodule-bearing bed, by Marion, Newberne, Greensboro, Cocke's Mill, etc., to Eutaw, and from correspondents I have also received specimens from Pleasant Ridge and Pickensville. Subsequently, Judge Lawrence C. Johnson, of the U. S. Geological Survey, followed the line of outcrop of these beds far into Mississippi.

Between Hamburg and Cocke's Mill, six miles west of Greensboro, the greensand bed has substantially the same characters as at Hamburg, and the phosphatic nodules are also similar in quantity and quality to those already described. I have given below a number of analyses of the different kinds of phosphatic materials occurring along this line. There is no reason for thinking that the occurrence is not continuous between Hamburg and Cocke's Mill, or indeed to the Mississippi line. See analyses 49 to 60, (page 30).

On the Warrior river these deposits are again seen at Choctaw Bluff and at the old Erie landing. At both places the greensand is found immediately underlying the lowermost beds of the Rotten Limestone. At Erie, curious stalagmitic masses of indurated sand are formed in the loose sands which fall down the face of the bluff, the cementing principle being, as analysis shows, phosphate of lime. Analyses are found in the subjoined table Nos. 61 and 62, (page 30).

At Eutaw the greensand bed is well seen in the railroad cut near the depot. This greensand contains some imbedded phosphatic nodules, but the greater part of the nodules are to be found in a whitish sandy calcareous matrix, also seen in the railroad cut; at a well in the fair grounds; in a field east of town, belonging to Mr. Kirksey; and on the western edge of town at Mr. C. S. Bray's. In all these localities there are phosphatic shell casts, sharks' teeth, and the other fossils common to the phosphate beds elsewhere. Analyses of the materials occurring about Eutaw are seen in the table (page 30), Nos. 63, 64, 65, 66 and 67.

Specimens have also been received from Pleasant Ridge, from Mr. R. K. Horton, from the Turkey creek hills close to that town; and from Pickensville Mr. Walton Harrison has sent others. From both these localities, only nodules and phosphatic casts have come, but there seems to be no reason for thinking that the greensands are absent. For analyses see table (page 30) numbers 68 and 69.

Analyses of Specimens Occurring Westward from Hamburg.

	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYST.
Marion and Vicinity.					
49. Phosphatic casts, A. T. Moore	7.91	27.74	60.55	......	Laboratory A. & M. College.
50. Indurated phosphate rock, M. W. Oliver	7.61	11.05	24.12	......	“ “ “
51. Light colored greensand, M. W. Oliver	......	2.98	6.50	......	“ “ “
52. Dark bluish greensand, M. W. Oliver	......	2 57	5.61	......	“ “ “
53. Phosphatic nodules, Judge Bailey	25.91	26.74	58 37	33.55	“ “ “
54. Greensand, Carlos Reese	37.70	3.78	8.25	......	“ “ “
55. Phosphatic casts, Dr. W. W. Wilkerson	12.55	14 23	31.06	......	“ “ “
Newberne and Greensboro and Vicinity.					
56. Greensand, E. N. Driver, Scotts Station	......	2.36	5.15	......	“ “ “
57. Nodules and phosphatic casts, Mrs. Jemison	10.85	23.10	50 43	......	“ “ “
58. Phosphatic casts, Chas. W. Turpin	7.73	26.54	57.94	......	“ “ “
59. Phosphatic casts, Dr. J. B. Reid, Greensboro	16.22	23 20	50 64	39 34	“ “ “
60. Greensand, Cocke's Mill	......	4.30	9.38	......	Chas. Gibson, Chicago.
Warrior River.					
61. Greensand, Choctaw Bluff	......	5.03	10.96	......	W. I. Herzberg, Univ. of Ala.
62. Stalagmitic formation, Erie	......	1.16	2.53	......	D. W. Langdon, Jr., “
Eutaw and Vicinity.					
63. Greensand, from railroad cut, Eutaw	......	.60	1 31	......	Laboratory A. & M. College.
64. Indurated greensand, Fair Grounds, Eutaw	39.87	3 24	7.07	......	“ “ “
65. Nodules and casts, Kirksey's field	9.44	21.53	47.00	41.72	“ “ “
66. Greensand marl, T. J. Anderson, Eutaw	......	1.53	3.35	......	Eug. A. Smith.
67. Phosphatic nodules, A. W. Anderson, Eutaw	26 99	16.48	35.97	34.57	Laboratory A. & M. College.
West of Eutaw.					
68. Nodules and phosphatic casts, Pleasant Ridge	5.90	25.14	54.88	......	“ “ “
69. Nodules and phosphatic casts, Pickensville	4.21	22.40	18.90	......	“ “ “

EAST OF HAMBURG.

Mr. John Daniel, of the University of Alabama, went for me to examine the country east of Hamburg, and found the phosphates between Selma and Summerfield, and within a few miles of the first named place. From here he went into Autauga county, following the line of the outcrop of the phosphates as far as Prattville. Meanwhile I had received from several gentlemen near Selma specimens from a number of localities which proved to be phosphatic, and in Autauga county Mr. Leonidas Howard and Dr. S. P. Smith made tolerably thorough examinations of the vicinities of Mulberry and Prattville, where the greensand beds were discovered. The analyses of these greensands show that they are valuable fertilizers.

Along with the greensands are the usual phosphatic nodules and shell casts, and near Prattville also Col. Doster's farm and Dr. A. S. McKeithen's place, a hard phosphatic limestone, which may some day be utilized. From the vicinity of Wetumpka also came specimens from Mr. John Enslen showing that the greensand deposits extended in that direction also. Prof. Broun of Auburn has traced the outcrop of the phosphatic deposits through Macon and Russel counties almost to the Georgia line, but found them so deeply covered with the sands of the drift that they will hardly be utilized.

We thus see that the phosphate outcrops across the state probably without a break in the continuity, and with very considerable uniformity in composition, and it is almost certain that valuable greensands are to be had merely for the cost of digging them up, for this whole distance.

The following tables (pages 32 and 33) show the composition of the materials which have been collected from the various localities east of Hamburg:

1. *Selma, Summerfield and Vicinity.*

	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYST.
70. Nodules, from near Selma	......	26.1	56.90	......	John Daniel, Univer'ty of Ala.
71. " " "	......	25.8	56.24	......	" "
72. " " "	......	36 0	78.68	......	" "
73. " " "	......	38.0	82.84	......	" "
74. Matrix of nodules, from near Selma	......	5 05	10.11	......	" "
75. " " " "	......	3.98	8.67	......	" "
76. Greensand, three feet thick, J. R. Barker's Mill	......	3 60	7.85	9.70	Laboratory A & M. College.
77. Greensand, J. R. Barker's Mill	......	5.17	11.26	......	John Daniel.
78. Nodules, 3 m. S-E. of Summerfield, overlying greensand	2.67	25 59	55.85	......	A. & M. College Laboratory.
79. Greensand, near Selma, Jos. Hardie	......	5.22	11.39	......	" "
80. Nodules and casts, near Selma, J. H. Robbins	6.49	24 85	54 25	31.57	" "
81. Nodules and casts, near Selma, Keenan place	50.68	12 88	28.11	22.20	" "

2. *Autauga and Elmore Counties.*

Analyses 82 to 89 inclusive are from specimens collected in western Autauga by Mr. Leonidas Howard; 90 and 91 are from Day's Bend, sent by Mr. W. A. Gunter; 92 to 96 inclusive, from near Prattville, sent by Dr. S. P. Smith and John Daniel; and 97, 98 and 99, collected by Mr. John Enslen, of Wetumpka.

	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYST.
82. Hard Siliceous limestone, near Mulberry	57.17	0.78	1.70		Laboratory A. & M. College.
83. " " " with shell casts, near Mulberry	49.05	4.86	10.61	26.55	" " "
84. Clayey limestone, with greensand upper part, "		2.20	4 80	7.99	" " "
85. Clayey limestone, with greensand lower part, "		1.69	3.69	14 89	" " "
86. Greensand 10 inches thick, Mulberry		2.49	5.43	8.38	" " "
87. Greensand marl from well, Mulberry		6.67	14.56	7.57	" " "
88. Main greensand bed 3 feet thick, Mulberry		2 63	5 74		" " "
89. Phosphatic lime rock, Mulberry	1.97	2.10	4.52		" " "
90. White phosphatic marl, Day's Bend	43.79	4.10	8.95		" " "
91. Phosphatic casts and nodules, Day's Bend	19.52	20.77	45.34		" " "
92. Nodules, near Prattville		28.14	61.34		E. M. Harris, Univ'ty of Ala.
93. Nodules, near Prattville		32.0	66.76		" " "
94. Phosphatic shell rock, A. S. McKeithen, near Prattville.	52.72	11.24	24.49		D. W. Langdon " "
95. Matrix rock, Bear creek, " "	29 48	2.71	5.92		" " "
96. Greensand marl, " "	54.72	1.37	2.99		" " "
97. Greensand marl, near Wetumpka	66.15	1.52	3.31	4.33	Laboratory A. & M. College
98. White phosphatic marl, near Wetumpka	41.36	1 11	2.42	32.11	" " "
99. Clayey phosphatic marl, near Wetumpka	34.68	1.96	4.28		D. W. Langdon, Univ. of Ala.

It has already been said above that Prof. Leroy Broun, Jr., of Auburn, was sent to examine the phosphatic deposits in the eastern part of the state. His report to Prof. Stubbs is given in full in Bulletin No. 5 of the Agricultural Commission, and from this report I take the following notes:

The phosphatic formation was first recognized by Mr. Broun on the place of Mr. T. L. Nobles, S 36, T 17, R 23, and it consists of a greensand underlying the superficial loams and clays. The same greensand was also found at several other localities, as at Mr. Frank Howard's, S 22, T 16 R 23, also a mile east of Mr. Howard's and on the Mr. J. M. Comer's place four miles southeast of Tuskegee. Thence eastward the greensand bed was traced to Smith's Store, to within one and a half miles south of Society Hill, and within one mile of Marvin. The analyses which are presented (page 35) of the specimens collected by Mr. Broun, show that the marl is not very strongly phosphatic, and being moreover deeply covered by the sands of a later formation, is not likely to become of much importance.

The measurements of Mr. Broun show that the greensand is quite thick, averaging perhaps over six feet.

3. *Macon and Russell Counties.—Specimens Collected by Prof. Leroy Broun, Jr.*

	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	ANALYST.
100. Greensand, T. L. Noble's, Macon county	80.90	.45	.98	Laboratory A. & M. College
101. " F. Howard's, near Tuskegee	74.90	.31	.67	" " "
102. " Charlie Cr——, Calebee swamp	66.71	.77	1.68	" " "
103. " from well near Tuskegee	75.67	.59	1.23	" " "
104. " shell marl, A. Smith's, near Uchee	74.46	.59	1.28	" " "
105. " J. M. Comer's, near Tuskegee, first 8 inches	71.35	1.29	2.81	" " "
106. " J. M. Comer's, near Tuskegee, average of five samples, taken at depths down to eight feet *	78.78	.50	1.09	" " "
107. Ferriginous sand, below Comer's greensand	82.25	.70	1.52	" " "
108. Phosphatic rock, J. P. Morris', Society Hill	10.77	5.34	11.65	" " "
109. Greenish loam, Chattahoochee river, mouth of Uchee creek	71.00	.96	2 09	" " "
110. Blue clay, mouth of Uchee creek, Chattahoochee river	77.26	.21	.45	" " "

*In these samples the percentage of phosphoric acid decreases regularly with the depth.

2. THE LIVINGSTON, FORT DEPOSIT, UNION SPRINGS BELT.

The rocks of this belt crop out across the state, along the southern border of the prairie region, just as those of the first named belt, appear as a border along the northern edge of the prairies.

The localities are, of course, very numerous, and as some of the rocks, especially the hard crystalline limestone, appear to contain uniformly a high percentage of phosphoric acid, the aggregate amount of this substance is very great.

The mode of occurence of the phosphoric acid in the rocks of this belt is somewhat similar to that above described, viz: It is found impregnating the siliceous limestone and white calcareous marls, as well as greensand marls, and is also seen in concretionary masses of nearly pure phosphate of lime, and in the moulds and casts of fossils, which are all strongly phosphatic, having nearly the same composition as the nodular phosphates themselves. It is interesting to note in this connection that wherever the original substance of the shell is present in any of these fossil remains, as is the case with the *exogyras and gryphœas*, of the oyster family, so abundant throughout the prairie region, there is scarcely a trace of phosphoric acid.

In the vicinity of the Tombigbee and Alabama Rivers the upper or Ripley group of the Cretaceous consists of the following well marked divisions:

First. Yellow sands about fifty feet, holding in many localities large beds of highly phosphatic shell casts.

Second. Dark gray micaceous sandy clays and clayey sands, about 100 feet thick, traversed by hard ledges of similar materials, and not very prolific of fossils. In these beds we find at many localities a bed of phosphatic greensand full of soft pulverized carbonate of lime. This greensand is some three feet or more in thickness, contains about 1.5 per cent. of phosphoric acid, and has been very successfully used as a fertilizer. This is probably the most important of the phosphatic materials occuring in this belt, and several analyses are given below, from which its composition may be seen.

Third. Thirty to thirty-five feet of a bluish argillaceous limestone, with great numbers of Cretaceous shells, which are, however, mostly in the form of casts, and strongly phosphatic. Along with these are irregularly shaped nodules of phosphate of lime, similar to those occuring in the Hamburg belt, and in most of the localities examined we find below this fossiliferous bed a stratum of siliceous limestone of very variable thickness, which also is strongly impregnated with phosphate of lime. It is quite possible also that some of the hard bands which traverse the sands next to be described are also phosphatic.

Fourth. Some sixty feet or more of sands of various colors, with indurated bands passing through them. As a rule, these sands are not very markedly fossiliferous, but the hard ledges usually hold great numbers of *exogyras* and *gryphæas*. As stated above, it seems probable that some of the siliceous phosphatic rocks, of which analyses are given (page 44), belong to this division of the Ripley. This seems all the more probable from the fact that the uppermost strata of the Rotten Limestone itself, which follow next below the sands in question, hold in some cases a very notable percentage of phosphoric acid. This is shown by the analyses of specimens collected from the vicinity of Livingston. These specimens were all taken from the surface, and appoar to be in most cases only the crumbling or disintegrating portions of the Rotten Limestone, and yet when the compact rock immediately underlying these phosphatic fragments is examined, it usually shows a very small proportion of phosphoric acid. In all cases the shell casts were phosphatic. The specimens about Livingston were collected by the writor in company with Dr. R. D. Webb, whose knowledge of the geological and topographical features of Sumter county is extensive as well as accurate. Many years ago Dr. Webb made analyses of some of these very materials, and in the newspapers called attention to the comparatively large percentage of phosphoric acid which they contained.

It seems further probable that throughout the Rotten Limestone there are beds in which the proportion of phosphate of lime is very considerable, or in which at least the shell casts are strongly phosphatic. This is shown by the analyses given (page 44) of phosphatic shell casts obtained from Boligee in Greene county, and from a locality between Newberne and Uniontown, seven miles from the first named place. Both of these localities are situated at some distance from the border of the Rotten Limestone.

Analyses illustrating the composition of the phosphatic materials occurring in the Rotten Limestone itself are given in the table (page 44), numbers 111 to 120 inclusive.

The phosphates of the strata which overlie the Rotten Limestone and which are included in the Ripley group have been examined from a number of localities below noted, and their description may perhaps be best given in geographical order. In describing the specimens, I shall endeavor to mark, as far as it is possible to do so, their geological position also by referring them to one of the four divisions of the Ripley group given on a preceding page.

Sumter County.--At Livingston, in addition to the phosphatic materials already mentioned as occurring in the Rotten Limestone itself, there is, at the negro graveyard about two and a half miles south-east of town, an outcrop of a siliceous limestone or calcareous sandstone strongly phosphatic, and a good many feet below it a clayey limestone with about half a per cent of phosphoric acid. The siliceous rock lies upon a hill of considerable height, and probably belongs to the upper part of the fourth or the lower part of the third division above given. The argillaceous limestone probably belongs to the Rotten Limestone. Analyses of these rocks are given in the table (page 44), numbers 118 and 121. Just across the bridge over Sucarnochee, on the road to York, the argillaceous limestone with phosphatized shell casts (third division above) outcrops along the road leading up the hill. None of these have been analyzed, but they are of the usual character.

At Coatopa the same clayey limestone may be seen on the land of Mr. John Wiatt. This rock has a good deal of glauconite and is highly fossiliferous, the fossils being mostly in the form of phosphatized casts. Analyses both of the limestone and of the shell casts have been made, numbers 122 and 123. In the same locality there is a highly calcareous greensand marl, full of lumps of pulverulent carbonate of lime. This material, by reason of its comparatively high percentage of phosphoric acid, as well as of carbonate of lime, will make an excellent fertilizer, where it can be had without much cost for freight. Analyses, numbers 124, 125 and 126, (page 44).

At Moscow, on the Tombigbee River, the strata of this horizon outcrop on the banks of the river. Here we have the siliceous rock, the clayey limestone and the shell casts, and a few miles north of the town, at Dr. Kelly's, the greensand marl. Analyses, numbers 127, 128, 129, (p. 44).

Marengo County.—In Marengo county the rocks of this horizon may be followed along a line leading from Moscow through Jefferson, Nixon's Store, etc. They occur near C. C. Shields, south of Dayton, and all along the Linden and Prairie Bluff road to the eastern border of the county. The materials which have been analyzed come, in this county, from two horizons, viz: The upper strata of the Rotten Limestone or the immediately overlying beds of the Ripley, and the sandy beds which form the uppermost division of the Ripley as above indicated.

1. Immediately south of the town of Dayton the soil is a strongly tenacious calcareous clay, imbedded in which are numerous clayey phosphatic concretions which are different from anything seen elsewhere. If found in sufficient quantity, these could no doubt be utilized, since they contain a very considerable percentage of phosphoric acid, as shown by the subjoined analyses, numbers 130 and 131, (page 44).

2. In the uppermost beds of the Ripley group, which are in the main yellow micaceous sands, there are at intervals beds of shells, or rather of the casts of shells, in some cases five or six feet in thickness. These shell casts are almost pure phosphate of lime, and as they are loosely imbedded in the sands and in large quantity, they may undoubtedly

be dug out, ground up and used with profit. Near Mr. Baileys's, between Dayton and Linden, there is at the Capt. Saunders place a thick bed densely packed with these shell casts. Also near C. C. Shields, on the road to Prairie Bluff, and on the Shiloh road there are many cuts worn by the roads in the yellow sands, and in these cuts these shell beds appear. An analysis of some of the casts from this locality appears on page 44, number 132.

Further south also in T. 15, R. 4, in a belt running east and west through the second tier of sections of the township, these shell beds are met with in many localites. One of the analyses (page 45) shows the composition of an average of the shell casts from three localities on Thos. Boozer's land. Number 133. These, as well as most of the clayey phosphates from near Dayton, were collected by Mr. Lawrence R. Smith, to whom I am also indebted for much information concerning the occurrence of the phosphatic material in Marengo county.

These shell casts appear to promise more than any of the other materials observed in Marengo, for they are found in sufficient quantity, are easily accessible, and if the composition in other localities is approximately similar to that of the specimens analyzed, they are rich enough in phosphoric acid. It seems probable that they will all be found to be very highly phosphatic, since the specimens from near Rehobeth from the same geological horizon show a similar composition. See analysis number 139, (page 45).

Wilcox County.—This phosphatic belt may be traced all along the northern border of the county from Prairie Bluff to Snow Hill. The phosphates appear to come from three distinct geological horizons, viz:

1. The argillaceous limestone with shell casts which make up the third division of the Ripley group. Everywhere at this horizon hard brown colored shell casts of phosphate of lime are seen wherever the limestone has been exposed to weathering. Samples of these phosphatic casts have been collected from Prairie Bluff, Old Canton Landing and vicinity, near Bridgeport, at mouth of Tear Up Creek,

and eastward out to Snow Hill, and associated with them at all these localities we find hard crystalline phosphatic limestone and calcareous sandstone, the limestone being in places very siliceous, so as to approach sandstone in composition. We have no analyses of the shell casts from Wilcox, but they are in all respects like those from Coatopa and other localities along this belt. At Prairie Bluff there is a sandstone much used for building purposes, which has a good deal of phosphoric acid, averaging perhaps .5 of a per cent. See analysis (page 45), No. 134.

The siliceous limestone, which may be a variety of the preceding, is more strongly phosphatic, and a specimen from a locality about a mile north of Prairie Bluff contained over 8 per cent. phosphoric acid. No. 135. A similar phosphatic sandy limestone from John Pettway's land, in Gee's Bend, has even more. See No. 137, (page 45).

A somewhat similar rock, but less strongly phosphatic, was analyzed from Mr. J. T. Beck's land near Bridgeport. No. 136, (page 45).

Again, at Snow Hill the same rock, a specimen of which from L. Moore contains nearly 10 per cent. No. 142, (page 45).

2. In the upper strata of the Ripley group in all these localities occur the phosphatic shell casts, analogous to those described from near Shields, in Marengo, and in the eastern part of the county near Snow Hill, the phosphatic greensand, which is probably analogous to that occurring at Coatopa and near Moscow. Some of the shell casts from Rehobeth, a few miles north of Prairie Bluff, have been analyzed and contain over 23 per cent. of phosphoric acid. No. 139. Associated with these casts are numerous rounded lumps of a sandy calcareous character containing some phosphoric acid. No. 138, (page 45).

The greensand has been best tested, both by analysis and by actual field experiment, from the bed occurring at W. S. Purifoy's, Snow Hill. This contains about 1.5 per cent of phosphoric acid, but a large percentage of carbonate of lime in loose, easily crumbled form, and will be one of the most valuable of natural fertilizers where it can be spread upon the soil without too much expense. See No. 140, (page 45). This is analogous to the greensand marl from near Coatopa, and from various localities in Dallas contiguous to the Wilcox line, as shown below.

There is an indurated bed usually associated with the greensand which contains even a higher percentage of phosphoric acid, as may be seen from the analysis No. 141, (page 45).

Dallas County.—The same rocks occur along the southern line of this county at Tilden, Richmond, Carlowville, Minter Station, etc., where we find both the greensand bed and below it the siliceous phosphatic limestone or calcareous sandstone, of which several analyses are presented. From these it will be seen that the limestone has a very variable composition. Nos. 144, 145, 146, 147, 151, 152, 154, (pages 45-6). With this are everywhere found phosphatic shell casts. No. 153, (page 46). The greensand marl appears to be of more uniform composition, as shown by analyses Nos. 143, 148, 149, 150, (pages 45–6).

Lowndes County and Eastward.—Beyond Dallas county very few examinations have been made, but some specimens have been sent to the University which show the existence of this line of phosphatic rocks nearly to the eastern line of the state. The phosphatic greensand crosses Lowndes a short distance below Bragg's Store.

Between Fort Deposit and Calhoun Stations the siliceous limestone occurs sometimes in rounded, apparently waterworn fragments, one of which has been analyzed. No. 155, (page 46).

Again, at Strata, in the northern part of Crenshaw county, we find the same rock. Analysis No. 156, (page 46). Along with it are great numbers of phosphatized shell casts.

At Olustee Creek, in northern Pike, a limestone with a moderate proportion of phosphoric acid has been found, but the main phosphatic belt will probably be found further north in the lower part of Montgomery county. See analysis 157, (page 46).

The crystalline limestone of Chunnenugga Ridge at Union Springs, in Bullock county, is also phosphatic, as well as the limestone cropping out on the banks of Cubahatchee Creek in Macon county. No. 162 and 163, (page 46).

From Dr. C. B. Leitner, Flora, Bullock county, I get a number of specimens of a phosphatic clay marl, which although not very rich in phosphates, might yet be advantageously used where the cost of transportation and application to the soil would not be too great. For analyses see Nos. 158, 159, 160, 161, (page 46).

Along the Chattahoochee river, phosphates, nodules, etc., have been observed in small quantities at several places, *e. g.*, near mouth of Uchee Creek, on Mr. Blackman's place above Eufaula, etc., but no analyses have yet been made of them.

The tables on pages 44-6 show at a glance the composition of the various materials above mentioned. They are arranged first, as to their geological horizon, and secondly, as to geographical position. The several materials are (beginning with the lowermost, geologically): 1st, a siliceous limestone of very variable composition, with which are associated numerous phosphatized shell casts. This appears at Moscow, at Prairie Bluff, in Gee's Bend, at Minter Station and at Snow Hill.

Above this we find in many of the localities a fine greensand marl containing about 1.5 per cent of phosphoric acid, *e. g.*, at Coatopa, near Moscow, at Tilden, and at Snow Hill. At Eufaula the dark gray micaceous marls have a small percentage of phosphoric acid. Analyses 164, 165, 166, p. 46. In these micaceous sands the greensand bed is located. The greensand is the most valuable of all the materials occurring in the Upper Cretaceous, unless it should turn out that the shell casts occurring in the uppermost sands (*e. g.*, at C. C. Shields and Bailey's, in Marengo, and near Rehobeth, in Wilcox,) are present in very great quantity, and, as now seems to be the case, very generally distributed throughout the country. This bed lies at a considerable distance above the siliceous limestone and shell casts above mentioned, the distance between the two being probably over 100 feet. The cast themselves are easily pulverized, unlike those occurring in the lower bed.

Phosphatic Materials from the Livingston, Coatopa, Snow Hill and Union Springs Belt.

NUMBER AND NAME.	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYST.
A.—Rotten Limestone.					
111. Nodules and shell casts, 7 miles south of Newberne	3.59	20.68	45.16	......	A. & M. College Laboratory.
112. Fossil casts from Boligee	2 98	27.76	49.68	......	" " "
113. Near railroad bridge in Livingston	11.90	.20	.43	......	" " "
114. Hill, 3¼ miles from Livingston, on Jones' Bluff road	53 16	.41	.86	......	" " "
115. Siliceous lime rock 4½ miles north of Livingston	39.52	.50	1.09	......	" " "
116. Concretionary nodules 3¾ miles north of Livingston	8.48	1.10	2.60	......	" " "
117. White clayey limestone 4 m. s-e. of Livingston, J. J Lee's	13.90	2.58	5.62	......	" " "
118. Clayey limestone, Negro graveyard, 2½ m. s-e. Liv'ton	25.30	.56	1.22	......	" " "
119. Clayey limestone, 6 m. s-e. of Liv'ton, Black Bluff road	15.02	.64	1.39	......	" " "
120. Phosphatic shell casts, same locality as 119	11.65	9.92	21 65	......	" " "
B.—Ripley Group, Overlying Rotten Limestone.					
121. Siliceous rock, Negro graveyard, 2½ m. s-e. Livingston, Sumter county	......	7.30	15.91	......	Eug. A. Smith.
122. Shell casts and nodules, Jno. Wiatt's, Coatopa	9.38	14 56	31 78	......	A. & M. College Laboratory.
123. Clayey limestone with greensand, same locality	25.74	5.01	10.93	......	" " "
124. Clayey phosphatic marl, same locality	51 25	2 24	4.89	......	" " "
125. Clayey phosphatic marl, another variety, same locality	......	.72	1.57	......	Eug. A. Smith.
126. " " " " " "	......	.74	1.61	......	" "
127. Siliceous rock, river bluff, below Moscow, Sumter co.	57.00	.28	.53	......	A. & M. College Laboratory.
128. Shell casts, " " "	25.52	1 55	3.38	......	" " "
129. Greensand marl, Dr. Kelly's, few m. n. of Moscow, "	......	2.52	5.50	......	" " "
130. Clayey concretions, white, in soil just south of Dayton, Marengo county	11.02	10.93	23.83	......	D. W. Langdon, Jr.
131. Clayey concretions, dark gray, just south of Dayton, Marengo county	21.41	17.32	37.76	......	" "
132. Shell casts, C. C. Shields', near Dayton, Marengo county	......	19.00	41.62	......	Eug. A. Smith.

Phosphatic Materials from the Livingston, Coatopa, Snow Hill and Union Springs Belt.—Continued.

NUMBER AND NAME.	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYST.
133. Shell casts, T. J. Boozer's, T. 15, R. 4, Marengo county	......	25 43	55.43	....	Eug. A. Smith.
134. Calcareous sandstone, average of three analyses, Prairie Bluff, Wilcox county	......	.48	1.05	....	" "
135. Calcareous sandstone, 1 mile north of Prairie Bluff, Wilcox county	....	8.35	18.20	....	" "
136. Gray calcareous rock, J. T. Beck, near Bridgeport, Wilcox county	....	1.08	2.34	....	" "
137. Phosphatic limestone, J. H. Pettway, Gee's Bend, Wilcox county	......	12.49	27.23	....	" "
138. Sandy calcareous lumps, near Rehobeth, Wilcox co.	......	.40	.87	....	" "
139. Phosphatic shell casts, near Rehobeth, Wilcox county	......	23.52	51.28	......	" "
140. Phosphatic greensand, W. S. Purifoy, Snow Hill, Wilcox county	40.83	1.04	2.37	....	D. W. Langdon, Jr.
141. Indurated greensand, W. S. Purifoy, Snow Hill, Wilcox county	28.61	3 94	8.59	....	" "
142. Sandy phosphatic limestone, L. Moore, Snow Hill, Wilcox county	32.47	9.74	21.23	......	" "
143. Phosphatic greensand, J. B. Lang, Tilden, Dallas co	....	1.5	3.27	16.36	Eug. A. Smith.
144. Glauconitic limestone, J. Z. Hearst, Richmond, Dallas county	15.73	2.62	5.72	....	A. & M. College Laboratory.
145. Siliceous limestone, J. Z. Hearst, Richmond, Dallas co.	34.95	3.21	7.00	.....	" " "
146. Siliceous limestone, J. Z. Hearst, Richmond, Dallas co	40.16	5.94	12.96	....	" " "
147. Siliceous limestone, Dr. G. W. Kyser, Richmond, Dallas county	39.47	8.69	18.97	29 31	" " "
148. Greensand marl, from Dr. G. W. Kyser, Richmond Dallas county	35.23	1.43	3 22	18.66	D. W. Langdon, Jr.
149. Greensand marl, from Dr. G. W. Kyser, Richmond, Dallas county	37 98	1.24	2 70	16 88	" "

Phosphatic Materials from the Livingston, Coatopa, Snow Hill and Union Springs Belt.—Continued.

NUMBER AND NAME.	Insol'ble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYST.
150. Greensand marl, from Wade, Carlowville, Dallas co..	37.20	1.16	2.53	17.92	D. W. Langdon, Jr.
151. Glauconitic limestone, H. M. Smith, Minter Station, Dallas county....	17.38	.74	1.62	......	A. & M. College Laboratory.
152. Siliceous limestone, Col. N. H. R. Dawson, Minter Station, Dallas county....	42.46	1.43	3.12	......	“ “ “
153. Phosphatic shell casts, Col. N. H. R. Dawson, Minter Station, Dallas county....	10.72	16.90	36.89	......	“ “ “
154. Phosphatic limestone, Col. N, H. R. Dawson, Minter Station, Dallas county....	......	12.41	27.05	......	John Daniel.
155. Sandy crystalline limestone, Ft. Deposit, Lowndes co.	......	13.55	29.54	......	Eug. A. Smith.
156. Sandy crystalline limestone, Strata, Crenshaw county.	......	6.22	13.56	......	Eug. A. Smith.
157. Sandy crystalline limestone Olustee creek, Pike county.	41.96	1.14	2.49	......	A. & M. College Laboratory.
158. Dark colored clay marl, C. B. Leitner, Flora, Bullock county....	87.25	.53	1.16	1.15	“ “ “
159. Yellow colored clay marl, C. B. Leitner, Flora, Bullock county....	67.25	.81	1.76	12.02	“ “ “
160. Dark colored clay marl, C. B. Leitner, Flora, Bullock county....	77.48	.76	1.66	8.20	“ “ “
161. Dark gray clay marl, C. B. Leitner, Flora, Bullock county....	77.02	.66	1.44	12.32	“ “ “
162. Hard limestone, 9 miles south of Tuskegee (mean of 3 analyses) Macon county....	......	.38	.82	......	“ “ “
163. Hard limestone, on Cubahatchee creek, Macon county.	......	.51	1.11	......	“ “ “
164. Gray micaceous sandy marl, J. W. Tullis, Eufaula, Barbour county....	80.14	.44	.96	......	D. W. Langdon, Jr.
165. Light gray, indurated sandy marl, J. W. Tullis, Eufaula, Barbour county....	......	.18	.39	......	“ “
166. Gray micaceous sandy marl, J. W. Tullis, Eufaula, Barbour county....	76.19	.27	.59	......	“ “

THE TERTIARY FORMATION.

General Characters and Sub-Divisions.

The whole thickness of the strata of the Tertiary formation on the Alabama and Tombigbee Rivers is between 1,620 and 1,700 feet, while on the Chattahoochee it is about 1,200 feet.

We have adopted the following four-fold division of the Tertiary:

(4) The White Limestone.
(3) The Claiborne.
(2) The Buhrstone, and
(1) The Lignitic.

The general characters of these sub-divisions are given below in the order of their relative ages, *i. e.*, beginning with the oldest.

(1) THE LIGNITIC.

This is the most massive of the sub-divisions of the Tertiary, having a thickness which can hardly be less than 900 feet. It also presents a greater variety in mineral composition, as well as in fossils, than the other divisions. In the most general terms, the Lignitic strata are cross-bedded sands, thin bedded or laminated sands, laminated clays and clayey sands, and beds of lignite, as well as liginitic matter which merely colors the sands and clays. With these are found inter-bedded at several horizons strata containing marine fossils. For the sake of greater convenience of description we present this Lignitic division in seven sections, each of which is characterized by one or more beds of marine fossils included in it. These sections are as follows, beginning with the lowest or oldest:

(a) The Midway or Pine Barren section; Clayton limestone.—The thickness of this section along the Alabama and Tombigbee Rivers is perhaps 25 feet. The strata are a white argillaceous limestone holding a large fossil of the nautilus family, which is characteristic of the horizon, calcareous sands and a crystalline limestone with *turritellas*, *carditas* and *corals*. This section is best seen in eastern Wilcox on Pine Barren Creek, and in adjoining part of Butler in the Little Texas region, but the upper or Nautilus rock occurs at Midway on the Alabama River and westward across Marengo. In going eastward we find the rocks of this section increasing in thickness till on the Chattahoochee it includes over two hundred feet in thickness of limestones and other calcareous strata.

(b) The Black Bluff section.—We find some difficulty in determining the exact thickness of the strata of this section, since on the Tombigbee the strata outcrop over a surface which would, with uniform dip, correspond to a thickness of over two hundred feet; while on the Alabama, and more particularly inland in the eastern part of Wilcox county, the thickness is not greater than thirty-five or forty feet. Since 80 feet of these beds are seen in superposition at one locality, (Black Bluff) we think that the maximum thickness cannot be less than one hundred feet.

The characteristic strata of nearly the whole of this section are black or very dark brown clays, which are in part fossiliferous. These clays underlie the *Flatwoods* of western Alabama and Mississippi, but towards the east they become much more calcareous and form the basis of some fine farming lands with black limy soils. This section has not been identified eastward of Butler county.

(c) The Naheola and Matthews' Landing section.—It is difficult to give the exact thickness of the strata of this section also, since it varies on the two rivers Alabama and Tombigbee, and thins down towards the east and does not appear at all on the Chattahochee. We have placed the thickness at one hundred and thirty to one hundred and fifty feet; the strata are gray sandy clays in the main, alternating with cross bedded sands. The beds of dark sandy and glauconitic clays containing marine fossils lie at the base of the section. At Naheola, on the Tombigbee, the upper and more glauconite part of the bed is most prominent, while at Matthews' Landing, on the Alabama, the lower part of the bed, dark gray sandy clays form the bluff.

(d) The Nanafalia and Coal Bluff section.—The strata of this section are 200 feet in thickness and consist of about 50 feet of gray sandy clays at top, which show a tendency to indurate into tolerably firm rocks resembling very closely some of the strata of the Buhrstone. Below this, about eighty feet of sandy beds, often strongly glauconitic characterized throughout by shells of a small oyster, *Gryphæa thirsæ.* Near the base of this sandy division there is a bed about twenty feet thick literally packed with these shells. Below the Gryphœa thirsæ beds follow some seventy feet of cross-bedded sands, glauconitic and apparently devoid of fossils, including about ten feet above the base of the section, a bed of lignite which varies in thickness from four to seven feet, The Nanafalia section retains its thickness and general character across the state to the Chattahoochee.

(e) The Bell's Landing or Tuscahoma section.—This is 140 feet in thickness on the Alabama and Tombigbee rivers, and this thickness is retained across the state to the Chattahoochee. The lithological characters also are practically the same throughout, but in the western part of the state the section includes two important beds of marine fossils and a third quite small and apparently unimportant. Towards the east these beds disappear. These fossiliferous beds are interstratified with yellowish sands in the upper and rather heavy bedded sandy clays in the lower part of the section. The upper marine bed, called the Bell's Landing marl, is about ten feet in thickness, and has forty feet of sandy strata over it. The middle bed is called the Gregg's Landing marl, and it is twenty to twenty-five feet below the preceding; it is about five feet in thickness. The lowermost of the fossiliferous beds of this section is only about one foot in thickness and lies about fifty feet below the Gregg's Landing bed. It is highly glauconitic, but does not contain any great variety of fossils. The Bell's Landing marl is distinguished from all others in Alabama by the great size of the shells which it contains. Eastward of the Alabama river there are very few fossils to be seen in the strata of this section.

(f) The Wood's Bluff or Bashi section.—This is 80 to 85 feet in thickness. The uppermost 30 feet consist of brown clays passing into a greensand, which holds a great variety of finely preserved marine shells. Below this greensand marl are dark gray sandy clays with four or five thin beds of lignite within the first twenty-five feet, succeeded by about 30 feet of cross-bedded sands, with a two foot seam of lignite at the base. This section extends entirely across the state to the Chattahoochee, where it is, however, considerably less in thickness and comparatively wanting in well preserved fossils.

(g) The Hatchetigbee section.—This section is 175 feet in thickness and is made up of sandy clays of prevailing brown colors varied with purplish shades, and containing three or four beds of marine shells in the uppermost 75 feet, and of somewhat similar purplish brown clays nearly devoid of fossils in the lower 100 feet. All these brown sandy clays become much lighter colored upon drying and exposure to the weather. These clays extend across the state with somewhat diminished thickness, till on the Chattahoochee they are perhaps not thicker than 50 feet and are practically devoid of fossils.

2. THE BUHRSTONE.

The minimum thickness of this formation is 300 feet; the materials are almost altogether aluminous and siliceous, consisting of aluminous sandstones, claystones and quartzitic sandstones, with occasional thin beds of glauconitic sand. The few fossils which have been obtained from this division are mostly in the form of casts. They do not appear to differ specifically from that of the overlying division. On the Chattahoochee the thickness is less than 200 feet and the rocks are much more calcareous and hold a greater number and greater variety of fossils.

3. THE CLAIBORNE.

The thickness is 140 to 145 feet; the materials are sands and clays, which are generally calcareous and often glauconitic. Near the top of the sub-division is a bed of glauconitic sand, 15 to 17 feet in thickness, filled with shells in a perfect state of preservation. The sandy clays forming the lower 50 feet are likewise filled with a great variety of shells in a good state of preservation. The intervening calcareous clays and calcareous sands are distinguished by the great number of shells of *Ostrea sellæformis* which they hold, as well as by the comparative rarity of other forms. On the Chattahoochee the thickness is not greater than 75 feet, and the bed with Ostrea sellæformis appears to be the only representative.

4. THE WHITE LIMESTONE.

This subdivision is calcareous throughout, but the lowermost 60 feet are more argillaceous than the rest. The minimum thickness is 350 feet, of which the uppermost 150 feet consist of a tolerably pure but somewhat siliceous limestone filled with coral masses.* The next succeeding 140 feet or more are made up of a soft white limestone, often quite pure and filled with *Orbitoides Mantelli.* The lowermost 50 feet are of impure, argillaceous limestone, which in disintegrating yields a black calcareous soil similar to that derived from the Rotten Limestone of the Cretaceous. This lower portion of the White Limestone surpasses the others in the variety of its fossil contents. On the Chattahoochee the rocks are more uniform in composition and are about 275 feet in thickness.

Phosphates of the Tertiary Formation.

In the summer of 1884 Mr. D. W. Langdon, Jr., of the State Geological Survey, discovered at St. Stephens, and subsequently at several other localities, representing different geological horizons, phosphatic marls and nodules. Since that time other examinations have disclosed the fact that phosphatic material exists in at least four different geological horizons, viz: In the Black Bluff and Nanafalia groups of the Lignitic; in the White Limestone; and in eastern Alabama, at Ozark, in the strata of the Claiborne group.

1. *Black Bluff Group.*—In the eastern part of Wilcox county the prairie clays derived from the disintegration of this group are highly fertile, and though no analysis of any

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*This upper part appears to be entirely local and has not been seen except in Clark county, below Jackson. Leaving this out of account, the thickness of the white limestone is some 200 to 300 feet.

of these soils has yet been made, it is probable that they are exceptionally strong in phosphoric acid, for they are in places filled with irregularly shaped concretions or *coprolites* which are chiefly phosphate of lime. One of these specimens analyzed by me, from the mouth of Bonner's Lane, contains 27.632 per cent of phosphoric acid, equivalent to 60.238 of bone phosphate. Analyses No. 167 (page 55). Immediately above the clays here alluded to are several sandy beds, which, in part, are pretty firm sandstones. One of these sandstone beds is more persistent than the others, and appears along the hillsides, near Allenton and elsewhere in eastern Wilcox, in little cliffs which look like low walls. This rock has in places a large number of phosphatic concretions, very like those above described as occurring in the clays below. I have made two analyses of this rock, the one from the "Grave Yard Hill," a few miles west of Allenton on the upper Camden road, and the other from the mouth of Bonner's Lane. Both are hard, yellowish, sandy limestones, that from the first locality being pretty free from the phosphatic nodules, that from the other containing a notable quantity of them. The rock from the Grave Yard Hill had 0.3 per cent. of phosphoric acid only, while that from Bonner's Lane contained 3.71 per cent. Analyses No. 168, 169, (page 55).

This formation runs eastward into Butler, where, however, it has not as yet been examined.

2. *The Nanafalia Group.*—The important bed in this division of the Lignitic is a deposit of shells of a small oyster, called *Gryphœa thirsœ.* While this shell is found generally distributed through sixty feet or more of the strata, there are in most localities of its occurrence beds from 15 to 20 feet in thickness, consisting of an almost solid mass of these shells packed in greensand. At intervals in these beds there are bands much harder than the rest of the beds, and these hardened bands appear to be generally pretty strongly phosphatic. Mr. Langdon analyzed a specimen from Nanafalia of one of these hard ledges and found 6.701 per cent of phosphoric acid in it. Analyses No. 170, (page 55).

The softer parts of this marl, as well as of the other marls which characterize the Lignitic division of the Tertiary, appear, as a rule, to have a very inconsiderable percentage of phosphoric acid. Several of them, however, would make good fertilizers because of the large amount of pulverulent carbonate of lime which they hold; especially is this the case with the Nanafalia and Wood's Bluff marls.

3. *The Claiborne.*—In the eastern part of the state the Claiborne division of the Tertiary includes in places a bed of shell marl, which holds a very considerable percentage of phosphate of lime. This bed is best seen in the cut made by the Midland railroad, a short distance from Ozark in Dale county, where this road passes under the Savannah & Western R. R. (Georgia Central). This bed about five feet in thickness contains also a large amount of carbonate of lime, and would unquestionably benefit the soils about Ozark if spread liberally upon them.

The section exposed here is as follows:

(1)	Gray surface sands	3 to 4 feet.
(2)	Red clay loam	6 to 8 "
(3)	Light colored laminated clay	5 "
(4)	Dark bluish pyritous sands	5 "
(5)	Black or dark gray joint clay	3 "
(6)	Greensand marl filled with shells, which are mostly of one species, a *cytherea*. This bed is phosphatic	5 "
(7)	Black sandy clay to bottom of the cut	4 "

The bed No. 6 is the one referred to, and though it has been seen by me only at this place, there is no doubt that it underlies a large area and will be found outcropping along the ravines about Ozark.

4. *The White Limestone.*—In the lower beds of this formation at St. Stephens, Mr. Langdon first saw the phosphatic marl. It occupies the lower fifty or sixty feet of the division, corresponding to the Jackson formation of Hilgard and other writers. In this limestone there are phosphatic marls, as well as nodular masses of phosphate of lime. Where the disintegrated marl forms the surface, a very productive and

lasting soil is the result. The fertility of the soils of the "Lime Hills" of Clarke, Washington and Choctaw counties is well known, and the same class of soils is found in the prairies of western Mississippi, which join the lime hill regions of Washington and Choctaw. In this state the topography of the region is rather broken, so that the soil washes badly.

The marl first analyzed from St. Stephens contains 1.14 per cent. of phosphoric acid, and a nodular mass from the same locality contains 22.68 per cent., or about as much as the average nodules of the Cretaceous formation. Nos. 171 and 172, (page 55).

A cream colored calcareous rock from near Coffeeville, of presumably the same horizon, contains 2.743 per cent. No. 173, (page 55).

In many places in Clarke county, where the lower part of the White Limestone forms the surface, these nodules are common. One has been analyzed from near Grove Hill, having 19.48 per cent. of phosphoric acid. No. 174(page 55.) I have, however, nowhere seen them in sufficient quantity to make them of any importance. The marl, on the other hand, might be very advantageously used where it is convenient to the fields upon which it could be spread without too great cost.

The upper part of the White Limestone seems to be comparatively barren of phosphatic materials. The average of a good many analyses made of this rock shows no more than about 0.1 per cent. of phosphoric acid.

So far as examined up to this time, none of the Tertiary materials of Alabama are very promising for phosphates. Florida, on the other hand, abounds in phosphatic limestone and marl, but they are, in all probability, in every case, of Miocene age, later than the Tertiary of Alabama. Examinations made of the Eocene limestone of Florida (of same age as the Alabama rock) likewise show very little of phosphoric acid.

None of the materials from the Claiborne and Buhrstone divisions, except the shell bed at Ozark, Dale county, above mentioned, have as yet shown any notable amount of phosphate.

The following table will show the composition of the phosphatic materials from the Tertiary formation:

Table of Analyses of Phosphatic Materials from the Tertiary Formation of Alabama.

NAME AND LOCALITY.	Insol'ble Matter.	Phosphoric Acid	Bone Phosphate.	Lime Carbonate.	ANALYST.
167. Phosphatic nodule, Lignitic group, Bonner's Lane, Wilcox county	......	27.63	60.24	....	Eug. A. Smith.
168. Phosphatic sandstone, Lignitic group, Bonner's Lane, Wilcox county	....	3.71	8.00	....	Eug. A. Smith.
169. Phosphatic sandstone, Lignitic group, near Allenton. Wilcox county	......	.30	.65	....	Eug. A. Smith.
170. Indurated marl, Lignitic group, Nanafalia, Marengo county	19.31	6.70	14.61	....	D. W. Langdon, Jr.
171. Phosphatic marl, white limestone, St. Stephens, Washington county	12.00	1.14	2.47	68 32	"
172. Phosphatic nodule, white sandstone, St. Stephens, Washington county	4.51	22.68	49.45	13 79	"
173. Phosphatic rock, white limestone, near Coffeeville. Clarke county	6.44	2.74	5.98	72 01	"
174. Phosphatic nodule, white limestone, Grove Hill, Clarke county	1.55	19.48	42.47	....	"

PROBABLE ORIGIN OF PHOSPHATES.

The phosphates above described, especially those of the Cretaceous formation, in their geological position, mode of occurrence, and in the character of the material, resemble the phosphates of Cambridgeshire, England. These are found at several horizons in the formations immediately underlying the Chalk, viz: the Upper Greensand, the Gault, and the Neocomian, or Lower Greensand; the phosphate or "coprolite" beds appear always to mark horizons of unconformity, i. e., they seem to have been deposited upon the eroded surfaces of previously existing strata; they consist of casts of shells, bones, etc., mineralized by phosphate, and of shapeless masses of phosphate of lime; they are irregularly distributed through the matrix along with pebbles and other rolled masses; and many of the phosphatized casts are of fossils which belong to earlier formations than those of which they now form a part. (See T. G. Bonney, Cambridgeshire Geology, and W. Keeping; the Fossils of Upware, etc.)

So our Alabama phosphates of the Cretaceous formation occur at several horizons, and they occur at planes of unconformity. This is particularly noticeable in the case of the phosphates at the base of the Rotten Limestone. In western Alabama, along the Tombigbee River, from 800 to 1000 feet of Lower Cretaceous beds underlie the Rotten Limestone, the northern outcrop of which is at least thirty miles from the Coal Measures at Tuscaloosa, while eastward these underlying beds seem to thin out so that at Wetumpka the phosphate bearing beds almost lap over upon the Metamorphic rocks.

The fossil casts are worn into most irregular shapes, and are associated with the bones of saurians and the teeth of sharks. These phosphates are mingled with rolled or waterworn fragments of other rocks; especially is this the case in the southern phosphate belt. At Fort Deposit, or just south of it, is a ridge which owes its existence to the hard crystalline limestone of the Ripley group; the foot of this, and the plain north of it for several miles, are strewn with rounded and water-worn fragments of this siliceous limestone.

The specimen from Fort Deposit, of which an analysis is given above, was one of these rounded and water-worn fragments.

The same thing may be noticed at Strata, and probably at very many other similar localities. Speaking of the Chunnenuggee Ridge at Union Springs, Prof. Toumey says: "The north side of the ridge presents the appearance of an ancient sea-beach, waterworn, detached masses of limestone and calcareous sandstone, imbedded in sand, and presenting the appearance of having been washed for ages by the ocean waves." (2d Report on the Geology of Alabama, p. 136.)

It is thus seen that in all these respects the Alabama Cretaceous phosphate beds resemble those of England, and it is quite probable that many of the phosphatic shell casts are "derived" fossils, that is, they have been washed out of the beds of which they originally formed a part, and redeposited in the beds where they are now found. To decide this question, a thorough study of our Cretaceous fossils will be needed.

In South Carolina a very similar state of things exists, only the main phosphate beds are of Tertiary, or later, instead of Cretaceous age.

The explanation of the origin and mode of formation of the phosphatic deposits now most generally accepted, is that originally presented by Prof. Holmes, of Charleston, which is thus well summarized by Dr. U. C. Shepard, Jr.: "Accumulations of decomposed animal detritus and exuviæ were acted upon by carbonic acid water, which dissolved out the phosphates and transported them into calcareous earth, where they were precipitated and fixed by carbonate of lime.

This process was continued till the carbonate of lime was transformed into a rich phosphate of lime. The mass, originally soft and loose, hardened gradually, but under the wear and roll of water it was broken up and rounded into the phosphatic pebbles now found."

Prof. T. G. Bonney, (Geology of Cambridgeshire,) has given the following account of the process: "With regard to the mode of formation of these phosphatic casts, nodules, etc., we have to consider not only the probable source of the phosphate, but also the mode in which it has been concentrated into these "coprolites." Phosphate of lime in the form of the mineral *Apatite* is present in granite, gneiss, slate, talc, and chlorite schists, and several kinds of lava..... It is also present in the waters of numerous mineral springs. .... It has been detected in the waters of several rivers, and is probably present in all, as well as in the sea, though of course in small quantities. Again, phosphates (chiefly lime) are present in marine and other plants. In short, the various investigations that have been made show that it is almost universally present in organic and not unfrequently in inorganic bodies."

"Next, it has been shown by numerous experiments that phosphate of lime is soluble in carbonated water, and further, that phosphate of lime present in an organism, (plant or animal) is much more soluble than that in a mineral."

"Again, phosphate of lime dissolved in carbonated water is precipitated by ammonia, which is a result of decomposition of organic bodies." "It appears, then, to me, that the best explanation of these phosphatic nodules is to consider them formed by what, for want of a better name, we may call concretionary action. The excreta, softer tissues, and smaller bones of the Vertebrata, the bodies of numerous Invertebrata, many of which have left no other trace behind, the various marine plants which probably would flourish abundantly in a shallow sea, to say nothing of any apatite which might be present in the detritus wherein they were entombed, would furnish a considerable supply of phosphates; in fact, *cœteris paribus*, a shallow sea appears to me more likely to be rich in phosphates than a deep one. The phosphates of the more perishable parts of the above named organisms would be dissolved in the water permeating the mud of the sea bottom, which would also be supplied with carbonic acid from decomposition, and so the mud be saturated with a weak solution of phosphate of lime. Now, if at a certain point in the mud there were an excess of phosphate of lime, and especially if ammonia were being evolved at that point, the phosphate in the neighboring solution might be precipitated; and probably (for it seems to have often happened with other minerals) all the phosphates of the surrounding mass would be precipitated about the nucleus. I regard, then, these nodules as the result of a process which took place during a part of the Gault period, and was continued during the Greensand epoch; which began shortly after the death of the organism, and lasted for a long time; and I explain their abundance, as I have already said, by considering the seam as the riddlings of a considerable deposit. It is note-worthy how often a bed of phosphate nodules comes just above a more or less marked stratigraphical break. It appears to me, therefore, that the process of formation of these nodules is......very analogous to that of flint; both, in many cases, proceeded from the mineralization of sponges."

"It may not unfairly be asked, why, seeing that weak solutions of phosphate of lime must be almost always present in sea-water, are not phosphate nodules generally present in rocks. The answer to this is that phosphate nodules are far from rare, and that the difficulty is exactly of the same kind as exists in the formation of flint."

"It may be that local circumstances, as indicated above, have been favorable to slightly concentrating the phosphatic element in the sea-water; but without availing ourselves of this possibility we may fairly answer that the process of deposition from weak solutions, one of which we are very ignorant, is probably a complex process which requires several independent conditions to be fulfiled, so that it is but rarely that all are satisfied."

I have spoken above of the circumstances that casts of fossils are generally phosphatized, while those fossils, especially those of the oyster family, which retain their original shells, show scarcely a trace of phosphoric acid.

The purer limestones also, (i. e. those containing least

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clayey matters,) are usually very slightly, if at all, phosphatic. This circumstance is accounted for by Mr. Keeping, (Fossils of Upware) on the supposition that the purer carbonate of lime was uncongenial to the phosphate matter which was taken up more readily by the more argillaceous mud, which formed the impure limestones and which filled the cavities of the shells and produced the casts and moulds of which we have spoken.

The lesson to be learned from a careful study of the mode of occurrence of our phosphates, and of the conditions under which they have probably been accumulated, are obvious. We see that the formation of phosphatic deposits is not confined to any one geological period, but will follow whenever certain conditions, (some of which have been given above) are fulfilled. The association of phosphatic deposits with breaks or interruptions in the conformability of the strata, and the connection between the two, are also not without their practical bearings.

CALCAREOUS MARLS (NOT PHOSPHATIC) OF THE CRETACEOUS AND TERTIARY FORMATIONS.

For the sake of completeness we append here a short notice of certain calcareous marls, which have no unusually high percentage of phosphoric acid, but which can be advantageously used in agriculture where they are easily accessible.

Cretaceous marls.—In the upper part of the Eutaw formation, throughout the Rotten Limestone, and in the overlying Ripley, there are beds of calcareous matters which may be profitably used upon the fields where the cost of applying them is not too great. Most of these marls have been spoken of in connection with the phosphatic marls with which they are commonly associated, and there appears to be little need of adding to what has already been said.

Tertiary marls.—The principal horizon at which these materials occur are

(a). In the Nanafalia section of the Lignitic, already mentioned in connection with the phosphatic marl. This marl bed appear in the bluffs of the Tombigbee river at Nanafalia Landing in Marengo and thence for several miles down to Gay's Landing; on the Alabama it appears at Black's and Gullette's Bluffs and a short way up the river from the latter place. Between the two rivers this bed crosses Marengo and Wilcox counties and thence it may be followed eastward to the Chattahoochee river at Fort Gaines. This bed is prevalently a sandy bed with much greensand, loose shells, and occasional ledges with an excess of phosphate. It crops out at the foot of the Grampian Hills in many places. It is one of the most widely distributed and uniform of the marls beds of the state.

An analysis has been given (p. 55, No. 170), of a phosphatic ledge of this marl bed at Nanafalia, and I append here another analysis showing the general character of the formation. No. 175 (p.64) was taken from the Nanafalia Bluff. Wherever this marl occurs its presence is easily recognized by the vigorous growth of the shrubs and herbs. Its fertilizing action is everywhere naturally demonstrated.

(b) The Wood's Bluff or Bashi marl has been mentioned incidentally above. This marl occurs in its typical exposure at Wood's Bluff on the Tombigbee river. It is seen at the base of the Buhrstone hills in Choctaw county, in the town of Butler, near Pushmataha and in other places. Between the rivers it is seen along Bashi creek, near Choctaw Corner, below Lower Peach Tree, and at the Alabama river at Johnson's Island. Across the Alabama it appears in the lime lands below Bell's landing, along the lower prong of Flat creek, whose soils are by it made exceptionally fertile, thence into Butler by Sepulga, and Georgiana, across the lower end of Crenshaw into Coffee, appearing at Kimmey's Mill below Elba. Thence it may be followed to the Chattahoochee river, which it reaches about Zornville. But east of Coffee county, superficial sands cover the older rocks to such an extent that their only exposures are to be seen in the ravines and in the banks of creeks, etc. This marl, like the preceding, contains a large percentage of greensand, as well as of decomposed shells, which furnish carbonate of lime in very available form, almost pulvurent. There is no simple marl in the state that is in better condition for use upon the fields than the Wood's Bluff marl.

Many years ago Prof. Toumey induced Mr. Kilpatrick, at Wood's Bluff, to use this marl upon his garden, and his sons have told me that the effects of its use were plainly discernible for many years. One need, however, only notice the vegetation along the line of outcrop of this marl bed to be assured that it is a good fertilizer. The lime hills just below Bell's Landing, and the lowlands of Flat creek in Monroe, may be cited in confirmation of this statement. I give on page 64 two analyses of this marl, No. 176, taken from near Butler, in Choctaw county; the other, No. 177, from "the caves" near Choctaw Corner in Clarke county. At this last named place, as well as at Wood's Bluff, the marl is most conveniently situated for digging, and there is no reason why it should not be extensively used.

(c) In the Claiborne section there is no lack of good shell marls.

At the Claiborne Bluff itself the main shell bed of 17 feet in thickness was originally a greensand bed, but where this bed lies exposed to the weather it becomes oxidized and assumes a red or yellowish color. This bed, though packed with shells, has the interstices filled in with sand, and thus the percentage of silica runs up pretty high. Its value as a fertilizer depends solely upon the carbonate of lime of the shells, which is usually in not so available condition as in the case of the Woods Bluff marl. Analysis No. 178 shows the composition of this bed at Claiborne. Below this stratum follow many feet of calcareous beds, some of which contain large amounts of lime and are suitable for use as marls. No. 179 shows the character of these beds at the Claiborne Bluff, and No. 180 their characters at the Coffeeville Landing on the Tombigbee. (Analysis on page 64.)

Where this bed outcrops in the piney woods of Clarke and Choctaw, it causes the formation of what are locally called "piney woods prairies," i. e., limy fertile spots in the piney woods, a testimonial to the fertilizing qualities of the marl. At no place is this marl more easy of access than at the Coffeeville Landing.

(d) The White Limestone, as its name implies, is a calcareous formation. The lower part of this formation has generally the composition of an indurated marl similar to the Rotten Limestone of the Cretaceous. In its disintegration it yields a soil similar to that of the latter. These soils characterize the Lime Hills of Clarke, Washington, Choctaw, Monroe, etc. No. 181 shows the composition of this rock as it occurs in the upper part of the Claiborne bluff in Monroe county.

The upper part of the White Limestone formation contains a large amount of a soft chalky limestone that could easily be pulverized and rendered fit for application to the fields which it would undoubtedly, in almost every case, greatly benefit. This formation crosses the entire state and underlies the whole peninsula of Florida. It is easily dug up and cut when fresh, and for this reason is much used in the construction of chimneys, underpinning for houses, etc. Its composition is fairly well shown in analysis No. 182 (page 64), of a specimen taken in Clarke county a short distance north of Jackson.

Table of Analyses of Marls and Greensands, (not highly phosphatic) from the Tertiary Formations of Alabama.

NAME AND LOCALITY.	Insol'ble Matter.	Carbon-ate of Lime.	Potash.	Phos-phoric Acid.	ANALYST.
a. Nanafalia Section.					
175. Greensand marl, Nanafalia Land'g, Marengo county..	37.38	43.15	2.25	.04	H. M. Calley.
b. Wood's Bluff Section.					
176. Greensand shell marl, near Butler, Choctaw county...	67 84	24.74	1.03	.16	"
177. Greensand shell marl, Choctaw Corner, Clarke county	64.44	31.02	.46	.22	"
c. Claiborne Section.					
178. Shell marl, Claiborne Bluff, Monroe county..........	47.86	47 07	.33	.03	"
179. Greensand shell marl. Claiborne Bluff, Monroe county.	62.31	27.20	.63	.13	"
180. Greensand shell marl, Coffeeville Landing., Clarke co.	64.31	26 85	.37	.04	"
d. White Limestone Section.					
181. Soft white limestone, Claiborne Bluff, Monroe county.	31.31	62.42	.50	.09	"
182. Soft white limestone, near Jackson, Clarke county....	2.54	86.78	.35	31	T. W. Palmer.

ECONOMIC RELATIONS OF THE PHOSPHATES.

1. General statement of the quality of the Alabama materials, their quantity, and recommendations as to mode of application.

The commercial or agricultural value of the numerous varieties of marls existing in Alabama depends, 1st, upon their content of phosphoric acid, lime or potash; in other words, upon their fertilizing power; and 2d, upon their abundance and the cost of application to the soil; i. e., upon their availability.

The analyses already given will show the composition of many of our phosphatic marls, greensands, etc., as well as of the most important non-phosphatic calcareous marls.

From these analyses it will be seen that there are three grades of phosphatic materials found in the state, viz: *1st, Phosphatic nodules* and phosphatized shell casts, containing from 20 to 30 per cent. of phosphoric acid, and therefore to be compared with the high grade phosphates of South Carolina. *2d, Phosphatic greensands*, with very little carbonate of lime, averaging perhaps 4.5 per cent. of phosphoric acid, and with these might perhaps be classed the phosphatic siliceous limestone or calcareous sandstones which occur across the state in the latitude of Livingston, Prairie Bluff, Minter Station, etc. *3d, The greensands* containing only about 1.5 to 2 per cent. of phosphoric acid, but on the other hand, from 15 to 20 per cent of carbonate of lime in a loose pulverulent form.

We can probably best arrive at a conclusion as to the possible future value of these several grades of phosphates by considering each in turn.

a. The Nodules and other High Grade Materials.—Thse are too hard and insoluble to be used, except for the manufactures of superphosphate, unless ground to fine powder—"floats." They are equal to the Charleston phosphates in their percentage of phosphoric acid and in the absence of any large percentage of iron and alumina.

The experiments of Prof. Stubbs, made upon a number of samples of these nodules, and described in the Bulletin No. 5, of the State Agricultural Department, have shown that acid phosphates of good grade can be made out of the nodules, so that the only question of importance relates to their abundance.

In the vicinity of Hamburg and at some other localities these nodules lie loose upon the surface in large quantity, and probably represent the *debris* from the wearing away of the containing rocks during many ages, for in the matrix or containing rock of these nodules at Hamburg, the nodules were not found in place in sufficient quantity to be of importance. Similarly with regard to the phosphatized shell casts from this lowermost of the phosphate beds; they do not appear to be abundant enough to supply a manufactory of acid phosphate.

Again, just above the Rotten Limestone, we find similar shell casts which have the composition of the phosphatic nodules, and which, if abundant enough, could be used in the manufacture of superphosphate.

Lastly, in the uppermost beds of the Cretaceous formation, interstratified with yellow and gray sands, we find in the northern part of Marengo and Wilcox counties, very considerable beds compactly filled with these phosphatic casts, an average of which shows over 20 per cent of phosphoric acid. These casts are much softer and more easily reduced to powder than those occuring at lower horizons in the Cretaceous formation, they could be used in the manufacture of acid phosphate, and they appear, so far as examinations have gone, to be in sufficient quantity. At a few localities certainly, they make almost compact beds several feet in thickness, and a further investigation is much to be desired, and promises well.

b. The Greensands.—Under this head we shall consider both classes of greensand, viz: Those with very little carbonate of lime, and those containing 15 to 20 per cent. and above of it.

Among the strata which immediately underlie the Rotten Limestone, and which crop out across the state in the belt which includes Eutaw, Hamburg, Wetumpka, etc., there is the highly phosphatic greensand already described in detail, and exhibited by many analyses. This bed is perhaps on an average, five feet in thickness, and certainly in the counties of Perry, Dallas and Autauga, and probably in the others also, is rich enough in phosphoric acid to be advantageously used upon the soil. It may be used alone, or better with vegetable matter of some sort. Prof. Stubbs, in the Bulletin above referred to, gives the following recommendations: "These sands can be used in large quantities without fear of injury, but it is best always that they be applied either upon soils rich in humus, or in connection with vegetable matter. Composted with stable manure and cotton seed, and the mixture covered with a thin layer of gypsum or thick layer of rich earth and permitted to remain for several months, is perhaps the best way to utilize them. In making such compost, large quantities of greensand must be used. I would recommend the following proportions:

100 bushels stable manure,
100 bushels cotton seed,
100 bushels greensand,

put up in the way and manner described for making composts in a former bulletin. This compost should remain up much longer than one prepared with acid phosphate—in fact, the longer the better--even twelve months would not be too long, provided the compost had been properly made, and under shelter."

These recommendations would apply also to the calcareous greensands which occur just above the Rotten Limestone and which contain a smaller percentage of phosphoric acid, but a much larger percentage of lime. These last named marls have been actually tested in the field and the results yielded have been of such a nature as to encourage the experimenter to continue the use of them on a much larger scale

This upper bed has an average thickness of three feet, and it is known to extend from Coatopa in Sumter county, past Snow Hill in Wilcox, to near Bragg's Store in Lowndes. having essentially similar composition throughout this distance.

In regard to quantity therefore, these two beds are sufficiently large to be profitably worked.

2. *Comparison in Detail of the New Jersey phosphatic Marls, with those of Alabama.*

We have said above that the Greensands of Alabama have essentially the same composition as those of New Jersey, which are so highly prized and universally used in that state, and our assertion was based upon a comparison of the published analyses of the New Jersey marls with those recently made from Alabama materials. Not to go too much into details, I have here taken the mean of a great number of analyses of the Alabama greensands, and placed them in comparison with the average from analyses of the New Jersey marls. And since the experience of farmers has shown that the marls are valuable first of all, in proportion to the percentage of phosphoric acid which they contain, I have made the comparison on the basis of this ingredient, calling attention where needed, to the percentage of carbonate of lime, which experience has also shown to be a very valuable constituent of all the marls.

A. New Jersey Marls.

1. The average marl from the Lower bed (New Jersey) contains 1.14 per cent. phosphoric acid, which is not high, but the marl contains in addition, 10 to 20 per cent. of carbonate of lime, in fine powder. "In the neighborhood of the marls where it costs but little more than the cartage, a great deal is used which is much poorer than this, but there is no trouble in finding millions of tons of this quality. It is used in larger quantity than the other varieties, and is remarkable for the permanent improvement it makes in the soil." (Extract from Report of State Geologist of N. J.)

2. The average of five analyses given as representing the green marls of the Middle Bed, shows about 2 per cent. of phosphoric acid. Many hundred tons of this marl

are shipped every day over the railroads to the different parts of the state.

3. The average of four analyses given as representing the composition of marls of the Upper Bed, shows about 3 per cent. of phosphoric acid. This marl is also shipped by rail to all parts of the state.

These averages are considered by the State Department of Agriculture of New Jersey, as showing the general character of the three grades of marl in use in that state.

For the sake of comparison, I have taken the means of a number of analyses of typical samples of the various marls occurring in Alabama, showing the average percentage of that most important constituent, phosphoric acid.

B. Alabama Marls.

The Hamburg Greensand.

The line of outcrop of this belt across the state, near Pleasant Ridge, Eutaw, Marion, Hamburg, Selma, Mulberry, Prattville, and Wetumpka, has already been given.

The locality at Hamburg has been much more closely examined than any other in the state, and a great number of specimens from there have been analyzed.

The greensand proper is about five or six feet in thickness, but associated with it is a bed of about the same thickness, which holds phosphatic nodules, and which itself is highly phosphatic. We shall call this the Matrix of the nodules, to distinguish it from the greensand.

(a). The Greensand. This varies very considerably in composition as may be seen from the analyses already given.

Excluding all the exceptionally high percentages, we find as the mean of eight analyses of the average typical greensand, 4.6 per cent. of phosphoric acid. The whole bed will in all probability sustain this average.

(b). The Matrix.—The analyses of eleven typical specimens give an average of 2.5 per cent. of the phosphoric acid.

Specimens from this bed have been collected and analyzed from Marion, Greensboro, Choctaw Bluff, Eutaw, Selma, Summerfield, and localities in Autauga and Elmore counties but no care was taken in selecting the sample, to separate the greensand from the matrix of the nodules, and the following analyses may be considered as representing the averages of the two combined.

The average of four analyses of specimens from Marion, show 2.9 per cent. of phosphoric acid; of three specimens from Eutaw to Greensboro, 4.2; of four specimens from between Selma and Summerfield, 4.46; of seven specimens from Autauga county between Mulberry and Prattville, 3.15; of three specimens from near Wetumpka, 1.15 of phosphoric acid. The average of these nineteen analyses, together with the twenty-one from Hamburg, forty in all, thus given as fairly showing the composition of this greensand at the different localities between Eutaw and Wetumpka, show 3.33 per cent. of phosphoric acid. and I am satisfied that the bed will sustain this average, or even show a higher percentage when a greater number of analyses is made.

The Livingston, Coatopa, Richmond, Fort Deposit Greensand.

This bed, as has already been said, comes to the surface in a belt approximately parallel to the preceding, but on the southern border of the prairie region. Associated with it are the phosphatized shell casts, and the siliceous phosphatic limestone which have been mentioned above.

The greensand has been examined at several points extending from Coatopa, in Sumter Co. to Snow Hill, in Wilcox Co., and it has pretty uniform characters through this whole distance. Its thickness is some four or five feet, and like one of the New Jersey marls, above described, holds in addition to the phosphoric acid, about 30 per cent. of carbonate of lime in a fine earthy powder.

The average of eight analyses of this greensand from various localities from Coatopa to Snow Hill, shows 1.44 per cent. of phosphoric acid, and over 30 per cent. of soft pulverulent carbonate of lime. The close approximation in composition of this greensand to some of the New Jersey marls, which have been so successfully used, would be a good recommendation of itself, but we have fortunately a few field experiments which have tested its value in a practical way. (These experiments are described below.)

While this marl contains much less phosphoric acid than the marl of the Hamburg belt, it will doubtless prove an efficient fertilizer by reason of the carbonate of lime which it holds in addition to the phosphoric acid.

The Nanafalia Marl.

In addition to the two great marl beds above described, of the Cretaceous formation, attention has recently been called to others in the Tertiary formation to the southward.

The most important of these, and one of the most important in the whole State, is the Nanafalia Marl, which appears on the Tombigbee river at Nanafalia Landing, Eureka Landing, etc., and on the Alabama at Black's and Gullette's Bluffs, but which may easily be traced across Choctaw, Marengo and Wilcox counties into Butler, and thence to the Chattahoochee river. This is a greensand marl, rich in carbonate of lime, and having a very considerable thickness, in places thirty to fifty feet, but the main bed is from fifteen to twenty feet. Some of the indurated ledges which traverse this marl bed, hold as much as 6.7 per cent of phosphoric acid, but the average will fall much below this, so that it might perhaps not be classed with the phosphatic marls at all; still, the physical condition of the marl, and its high percent of carbonate of lime, will make it one of the most valuable natural fertilizers in the State.

The analyses made, show from 40 to 70 per cent. of carbonate of lime.

The Wood's Bluff or Bashi Marl.

This bed of greensand with high percentage of carbonate of lime, appears at Wood's Bluff on the Tombigbee river, and at Johnson's Wood Yard, just below Bell's Landing on the Alabama river, and in many places in the interior of Choctaw, Clarke and Monroe counties. It has comparatively little phosphoric acid, but a large amount of carbonate of lime, and is usually in most excellent condition physically, being almost pulverulent, especially where protected by the indurated portions of the bed. Some tests have been made of it as a fertilizer in Clarke county, and the results have been very satisfactory.

The St. Stephens' Marl.

Lastly, at St. Stephens on the Tombigbee river, and extending across Choctaw, Washington, Clarke and Monroe counties, there is a clayey marl which appears as the basis of the "Lime Hills" soils which exhibit an exceptional degree of fertility. I have not heard of this marl being used as a fertilizer, but there is no doubt of its value upon the light and sandy lands which are found always close to it.

3.—Can our Phosphatic Marls be Profitably Used?

We have seen above that our marl beds extend over a great area and contain each a quantity of available marl sufficient for all our needs for many generations to come. As regards their quality we have seen that they are very similar to the marls so extensively used in New Jersey.

The question that now most concerns us is whether or not these marls can be profitably used upon our soils. I think this question can be affirmatively answered. 1st. Upon general scientific principles. 2nd. By noting the results attained by the farmers of other States, notably New Jersey, by the use of marls quite similar in quality to ours. 3rd. By giving the experience of the few among the farmers of our own State who have used these very marls upon their fields for the past five or six years.

1st. Objection has been urged even by chemists, that so small percentage of phosphoric acid, and that too in the insoluble form, can be of comparatively little benefit to the growing crop. In answer to this objection it may be said that the experience of New Jersey farmers, and of our own too, so far as it goes, has demonstrated beyond all peradventure, that marls with this small percentage of phosphoric acid and in this insoluble form *do actually* prove of benefit to crops and *have actually* brought the New Jersey soils from the condition of barren sands up to a degree of fertility which is not equalled by the soils of any other State of the Union.

It seems to me that this should be conclusive, but as I have time and again published these facts, and there still remains doubt as to the value of our phosphatic marls, perhaps an attempt to show *how* it happens may not be out of place.

Commercial phosphates are, as a rule, applied to the soil in a soluble form but experiments by Thenard have shown that when given to the soil in this form the phosphoric acid very speedily, (after the lapse of a day or two at most) goes into insoluble combinations with the iron, alumina, lime, or magnesia of the soil, and since the plant contains a very small percentage either of iron or alumina or lime or magnesia, it is certain that the phosphoric acid is not assimilated from these insoluble compounds until they are decomposed, and this decomposition appears, for the most part to be effected through the agency of the alkaline salts present in the soil, and partly also, as shown by the experiments and observations of Liebig, Heiden, Knop, and others, through the solvent action of the acid excretions of the plant roots themselves. The experiments show that the phosphoric acid of commercial super-phosphates, after two or three days in contact with the soil, is in quite as insoluble a form as the phosphoric acid of our marls. If the plant is able to assimilate the phosphoric acid from the first, it is certainly possible for it to do so from the second.

In the notice of Alabama phosphates in the report on the Mineral Resources of the United States for 1886, Dr. Day writes as follows: "Since the announcement of the discovery of the phosphates in 1884, it is remarkable that very little has been done towards utilizing these deposits. The chief reason for this seems to be the reluctancy to invest capital in an industry which can only turn out a product to be consumed locally. These phosphates and marls are, however, extremely valuable and there is absolutely no reason why they should not be used in much larger quantities than in the prosperous state of New Jersey, where of marls alone at least 800,000 tons by no means so rich in phosphoric acid, are annually applied to the soil. The questionable opinion seems to be prevalent that only such fertilizers can be used to advantage, in which the phosphoric acid is in a soluble condition. It is true that for quick benefit, such fertilizers give most immediate returns, but the employment of ground bones shows the benefit which can be obtained from the use of fertilizers in which the phosphoric acid is insoluble. In the phosphate rock of Alabama, the percentage of phosphoric acid is lower than in ordinary commercial fertilizers, and it is less soluble, but still the poorest of these marls contains many times the phosphoric acid of an ordinary rich soil. Therefore the question of ultimate benefit is simply as to how many tons of marl or phosphate must be applied per acre, to add to the soil as much phosphoric acid as is contained in the quantity of commercial fertilizers ordinarily applied. A serious difficulty in selling the phosphates and marls is offered by the state laws, which rule out of the market the only mineral substance which this state possesses."

2nd. I am aware that with many, and very naturally too, an opinion based upon general considerations has very little weight, and I therefore present the following from the experience of the New Jersey farmers in the use of materials similar to our.

The greensands of New Jersey have essentially the same composition as ours, as has been shown at length in division 2 above, and here are some statements taken from a Report of the New Jersey Board of Agriculture, showing what a complete revolution the use of these marls has worked in that state. "The marl has been of incalculable value to the country in which it is found. It has raised it from the lowest stage of agricultural exhaustion to a high state of improvement. Found in places where no capital and but very little labor were needed to get it, the poorest have been able to avail themselves of its benefits. Lands, which in the old style of cultivation had to lie fallow, by the use of marl produce heavy crops of clover and grow rich while resting. Thousands of acres of land which had been worn out and left in common, are now, by the use of this fertilizer, yielding crops of the finest quality. Instances are pointed out everywhere in the marl district of farms which, in former times would not support a family, but are now making their owners rich from their productiveness. Bare sands, by the application of marl, are made to grow clover and then crops of corn, potatoes and when. What were supposed to be pine-barrens, by the use of marl, are made into fruitful lands. The price of land in this region was considerably below that in the northern part of the state forty years ago; now that the lands are improved, their prices are higher than those in the northern part of the state, though even there they are higher than anywhere else in the United States."

In the winter of 1876–7, a series of questions relating to the quantity of marl used per acre, the benefits resulting from this use, the mode of application, etc., was sent out to the farmers of New Jersey, and from the answers received, detailing the results of experience, together with the chemical analyses of the marls, the following conclusions were drawn:

"1st. That the most valuable marls and those which will pay best the cost of long transportation, are those which contain the highest percentage of phosphoric acid.

"2nd. That the most durable marls are those containing carbonate of lime, the more the better.

"3rd. That the potash in the marl has but very little, if any, present value, it being combined with silica, and so insoluble.

"4th. That greensands containing but little of either phosphoric acid or carbonate of lime, become active fertilizers when composted with quick lime.

"5th. That marls which are acid and burning from containing sulphate of iron, can be rendered mild in properties and useful as fertilizers by composting with lime.

"7th. That crops particularly improved by it are all forage crops—grass, clover, etc.; for these the green marl may be spread upon the surface to the amount of from one hundred to four hundred bushels per acre. The crop is generally doubled, and in some cases quadrupled, by this application. Other marls must be used in larger quantities, but will produce good results."

3rd. With this statement of the chemical and physical characters of our Alabama phosphatic marls, and with the record of the experience of New Jersey farmers in the use of similar marls, which to say the least are no better than ours, (and all the analyses show them to be if anything inferior) can any one doubt that our marls, it properly used, will be of inestimable benefit to our farmers?

But we are, fortunately, not obliged to go out of the state for data to show that our marls are of value.

Since their discovery in 1884, four farmers residing in different parts of the state, have been induced to make thorough tests of them, and since these tests have been made with all the varieties of phosphatic marl above mentioned, and upon every variety of soil and in four widely distant localities, I think they may be taken as giving absolute practical proof of what we may expect from the use of these marls.

The greensands of the Hamburg belt have been tried at Eutaw by Mr. T. J. Anderson, the Coatopa marl by Mr. John Wiatt at Coatopa, by Dr. G. W. Kyser at Richmond, Dallas county, and by Mr. W. S. Purifoy at Snow Hill, in Wilcox county, and the Nanafalia marls by Capt. W. H. Homer at Mobile.

Mr. Anderson writes, (1886): "Last year my son and myself experimented somewhat with the marl and with good results. You remember the old field near the bed of marl was poor and worn out. It took an average of five acres to the bale of cotton. On one acre we put nothing but the marl, pulverized as well as we could do it with a good corn and cob crusher. We used about three quarters of a ton on that acre, and no other fertilizer. The result was 1200 lbs. seed cotton. On another acre we used the same amount of marl and 30 bushels of crushed cotton seed; result about the same. On another acre we used marl, stable manure, and lot scrapings with about the same result. To the poorest spot (about three acres) we then applied the marl mixed with coal and pine wood ashes; result about 600 lbs. seed cotton to the acre. We noticed that the marl did best on clay land, and that where it was used alone and freely, the long dry spell did not show its effect much.

We planted some cotton in an old road, nothing but clay, using the marl freely, and the stalks never did shed the foliage until frost. We are perfectly satisfied with the results and intend to use the marl more extensively this year. We also used it on Irish potatoes with fine results both as to quantity and quality. Also tried it on the sweet potatoes, but the result was unsatisfactory, more vines than "taters."

I may remark in connection with this extract that the material used by Mr. Anderson is not the greensand proper, with its high per cent. of phosphoric acid, but has rather the composition of the matrix of the nodules, say 1 or 2 per cent. The Hamburg greensand itself has never, to my knowledge, been adequately tested.

Mr. John Wiatt of Coatopa, writes (1886): ', In reply to your enquiry I will say that my experiments with the marl have been very satisfactory. You will remember that when you were here last, you suggested that I make an experiment with the clay marl alone by spreading it broadcast upon the land. I did this last year, on half an acre, applying at the rate of eight tons to the acre. Adjoining this on the same quality of land I used compost, about the same quantity and with but little better result than from the marl alone. I think where nothing but the marl was used, the dry weather affected the land less than where the compost was used. I notice that the lands where the marl has been applied for the last three years in small quantities in compost, are changing very much in color, growing darker, and where formerly it baked badly, thus preventing a stand of cotton, it is now entirely changed, having become soft and mellow, and therefore more productive. The result from the ground rock is much more marked."

In addition to this report from Mr. Wiatt I may say that when I visited his place two years ago, there were several spots in his field conspicuous by the deep green color of the foliage of the cotton plants, and the greater height of the stalks, nearly twice that of the plants in the rest of the field. On enquiry I was told that these were the spots where he had first thrown the marl in piles from which it was afterwards distributed over the rest of the field. In spreading the marl, the rest of the land received a good deal less than was left on these spots. There could hardly be given a clearer indication that the marl had been too sparingly used over the rest of the field, for the marl had not been left long enough in these piles to have brought about any such result by the shading of the soil beneath. I am glad to say that Mr. Wiatt took the hint and more than doubled the quantity of marl upon his field the next year.

Mr. W. S. Purifoy, of Snow Hill, was one of the first to make use of the marl, which, fortunately, was found very convenient of access upon his land. He has experimented with it every year since 1884, and has published at my request, the results of these trials each year. At this time, 1886, he writes: "There is one result attending the use of the marl of which I have not yet made mention, and that is that it improves the physical condition of aluminous soils, rendering them more easily cultivated; the loose nature induced by their application favors the germination of the seed, thereby securing a stand more readily. This condition of the soil is also favorable to the growth of the crop, in that it permits access of the atmospheric air, and brings about the conditions necessary to reduce the elements of the fertilizer to the form in which they are best suited to be taken up by the plants. To bring about these physical conditions, is in my opinion, no less important than to supply the elements of plant food. I have been using these marls on my lands with satisfactory results each year since their discovery. I apply it in connection with cotton seed and stable manure. Lands that had been exhausted and given up to sedge and briars, are now producing paying crops. Experience has shown the economy of bringing up lands gradually; which fact has induced me to pursue such methods as will render the land perceptibly more productive for each succeeding crop. To this end I have increased the proportion of marl in my compost heaps relatively to the other ingredients. The proportions as now used are as follows: Marl, 1,500 lbs.; stable manure, 300 lbs.; cotton seed, 200 lbs.; making one ton, which I apply per acre. With the lights now before me, I shall follow this plan in the future."

Mr. Purifoy's experiments, extended over a number of years, go to show that while the plants grow off more rapidly when fertilized with superphosphates, they stand the later drouths better and produce finally as good crops when treated with the phosphatic greensands.

Quite similar to Mr. Purifoy's is the experience of Dr. Geo. W. Kyser, of Richmond, Dallas Co., also extending over a number of years. He has used as fertilizers not only the greensand marl, but also a ground up phosphatic rock occurring on his place. Dr. Kyser made some comparative tests which are of interest. The commercial phosphates caused the cotton plants experimented with to grow off much faster than the ground rock and greensand, but on the other hand, those plants fertilized with the rock and greensand stood the drought much better and were green and flourishing at least three weeks after those treated with the commercial fertilizer had turned red and ceased making.

I have no report direct from Capt. Homer, but Mr. D. W. Langdon, Jr., informs me that he has for some years been using the Nanafalia marl, with great profit to himself, upon his market gardens in Mobile.

4. Limitations to the use of the marls depending upon their cost.

Even where a marl is known to exert a good effect upon the growing crop, the cost of getting it up and applying to the lands, might easily be greater than the benefits resulting from its use, and this is particularly likely to be the case where the marl is at a distance from the crop, and has to be transported by rail or wagon. There is in all these marls a very considerable percentage of inert matter, which very materially increases the cost of transportation.

We may make a rough approximation of the value of the phosphatic marls by assuming that the phosphoric acid is the only effective ingredient, and basing our calculations upon that assumption; if in addition, the marls contain a notable quantity of carbonate of lime, so much the better.

Available phosphoric acid is estimated now to be worth about 7.5 cents a pound, and we shall certainly be on the safe side if we put the value of the phosphoric acid of our marls at 5 cents a pound. With this valuation a marl with 1 per cent. of phosphoric acid would contain 20 lbs. to the ton, and be worth $1.00 a ton. A marl containing 2 per cent. would be worth $2.00, and so on.

With these data it might be easily calculated whether or not it would pay to apply a marl to the land. It would obviously not pay to transport any of the Alabama marls long distances by rail, with the present high rates of freight; but if experience should show that these marls were better than many of the commercial phosphates, the freight rates would certainly be reduced when the amount of traffic would justify it.

In looking over the Reports of the New Jersey farmers upon the cost of the marls in that state, we find that it varies from 40 or 50 cents a ton in the immediate vicinity of the pits, to $2.50 where it has to be hauled, say 10 miles. The farmers find that it pays even at the last named price, including all the cost of transportation, spreading, etc.

As to the value of the greensands as compared with stable manure, the New Jersey farmers vary in their experience. Some consider it equal to the barn-yard manure, load for load; some consider it better for certain crops, especially for grass; while others think one load of barn-yard manure equal to two, or even in a few cases, to three of the greensand.

We shall certainly not be overestimating its value when we consider our greensand to be worth about half as much per ton or load, as stable manure, and upon this assumption it will be easy for any person to determine for himself, whether or not it will be profitable for him to use greensand. All the above estimates refer to the immediate results to be gotten from the use of marls, but it should be borne in mind that the phosphatic greensands produce a lasting improvement of the lands upon which they are used, and the good effects of their use can often be seen for years after they have been applied to the soil. This should have some weight in estimating their value.

In the application of our marls, I do not think we can do better than to follow the practice of the New Jersey farmers, who use their marl either alone, spreading it upon the land in the fall and winter months, in quantity varying from 10 to 50 tons per acre, the more the better. In this form it answers well for clover, grass and other forage plants. Or they compost it with equal parts of stable manure, or with stable manure and quicklime, in which form it is a good fertilizer for all crops without exception.

It is sometimes urged as an objection to the use of the marls that our farmers need quick results and cannot afford to build up their lands for the benefit of posterity alone.

That this objection is absolutely without weight has been conclusively shown by the experiments of Mr. Purifoy, in which it was seen that while the crops fertilized with acid phosphate grow off a little more promptly *at the beginning* of the season, those upon which the marl was used in proper quantity quite equalled the first *by the end* of the season, so that even upon the first crop the marl proves of as much benefit as the commercial fertilizer, and there can be no comparison between the two as regards the permanent improvement of the soil.

These farmers throughout the state upon whose lands these marls occur, could not possibly be losers by giving the marls a thorough test in the field, on the contrary they could hardly fail to be gainers thereby. It is to them that we must look for the introduction of the marls into the agricultural practice of Alabama.

GEOLOGICAL SURVEY

OF

ALABAMA.

EUGENE ALLEN SMITH, PH. D., STATE GEOLOGIST.

BULLETIN No. 3.

A PRELIMINARY REPORT ON A PART OF

THE LOWER GOLD BELT OF ALABAMA,

in the Counties of Chilton, Coosa and Tallapoosa.

BY
WILLIAM B. PHILLIPS, PH D.
Prof. of Chemistry and Metallurgy, University of Alabama
and
CHEMIST TO THE SURVEY.

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To His Excellency,

THOMAS. G. JONES,

Governor of Alabama:

DEAR SIR:—I have the honor to transmit herewith Bulletin No. 3 of the Geological Survey, a Preliminary Report on Part of the Gold Region of Alabama, by Dr. William B. Phillips.

Very respectfully,

EUGENE A. SMITH,
State Geologist.

University of Alabama, May 1, 1892.

UNIVERSITY OF ALABAMA,
February 20th, 1892.

DR. EUGENE A. SMITH,
State Geologist:

DEAR SIR:—I beg herewith to submit a Preliminary Report on a part of the Lower Alabama Gold Field in the counties of Chilton, Coosa and Tallapoosa, prepared during the summer of 1891.

Very respectfully,

WILLIAM B. PHILLIPS.

PREFACE.

Specific interest in the Lower Appalachian Gold Field dates from June, 1540, when, according to Pickett's History of Alabama, Vol. I, pp. 10 to 15, Villabos and Silvera, two cavaliers from De Soto's army, (then encamped at Chiaha, the site of Rome, Georgia,) went with an Indian guide in search of gold. "About this time a principal Indian from Costa, a town below, informed De Soto that in the mountains to the north, at a place called Chisca, were mines of copper, and of a yellow metal, still finer and softer. Having seen, upon the Savannah, copper hatchets supposed to be mixed with gold, his attention was deeply aroused upon the subject. Villabos and Silvera, two fearless soldiers, volunteered to explore that region. Furnished with guides by the chief of Chiaha they departed upon their perilous journey." . . . . . They seem to have been gone some time for they returned in July. "Three days after this, Villabos and Silvera returned from Chisca. They passed into the mountains, found no gold, but a country abounding with lofty hills and stupendous rocks. Dispirited, they returned to a poor town, where the inhabitants gave them a buffalo robe, which they supposed once covered a tremendous animal, partaking of the qualities of the ox and the sheep. According to Garcelasso, the mines which they reached were of a highly colored copper, and were doubtless situated in the territory of the county of DeKalb."

This is the earliest prospecting trip for gold into the Appalachian Mountains of which I can find mention, and, like a great many subsequent trips of the same nature, resulted in the finding of "a country abounding with lofty hills and stupendous rock," but devoid of gold.

De Soto, while wandering in a somewhat aimless manner about the States of Georgia, Alabama and Mississippi, dining (when he could) on dogs which were said to be as toothsome as a fat wether, had his ears open for any report of gold or silver. He does not appear to have found any gold and all the silver obtained was secured *vi et armis* from the hapless Indians. Pickett says (ut supra, p. 91)

"The Creeks wore many ornaments of silver. Crescents or gorgets, very massive, suspended around the neck by ribbons, reposed upon the breast, while the arms, fingers, hats, and even sometimes the necks, had silver bands around them." This was in 1777, and it is not stated whether or no they had such ornaments in 1540. It is not likely that such was the case. I have in my possession now a silver crescent and a pair of silver bracelets obtained from some Indian graves in Coosa county, but they are evidently of foreign origin, probably English.

Of the thousand and one rumors of Indian silver mines along the Appalachian Range, from Winchester to Wetumpka, it is not likely that a single one is true. I have visited many localities from which the Indians were said to have extracted silver and have assayed samples of the so-called ore without finding more than the merest trace of gold or silver. What the pre-historic inhabitants might have done is irrelevant to the question; they did mine mica in North Carolina and Alabama and they did mine and treat copper ores. And the Indian, such as roamed these forests 150 years ago, mined and sold kaolin, exporting it from Jamestown. But I have found no evidence that the Indian of 1540 or of any other date, mined and treated either gold or silver ores. Nuggets of gold, picked up in some branch, are no proof of the mining of ore or the treatment of it when mined. De Soto's "copper hatchets, supposed to be mixed with gold" are illustrations of a great many other suppositions, equally baseless concerning the occurrence and distribution of the precious metals.

I have been unable to ascertain when gold was first discovered in Alabama, probably the year 1830 will approximate the true date. At any rate we know that shortly afterwards the placer or gravel washings became the seats of an active industry in the counties of Cleburne, Talladega, Randolph, Tallapoosa, Coosa, Chilton and, perhaps, also in Clay. But of the yield of gold there is no record, or indeed of anything in connection with the matter, except that at such and such localities large numbers of men were engaged in the work, and that at certain places it was said to be profitable.

No report on the subject has ever been issued by the State and, with the exception of the scattered remarks in Tuomey's Report of 1858, no notice has been taken of what I sincerely believe could be developed into one of the most successful enterprises in the State-gold mining. The present Geological Survey has acted wisely in devoting its attention mainly to coal and iron, for, with the meagre support afforded to it, little could be done by distributing the money over the entire State.

It is too small a piece of butter to be spread over a great deal of bread. The last Legislature, however, added to the means at the disposal of the survey and the first thought of the Director was towards the metamorphic region of the eastern part of the State, comprised within the limits already given and including about 3500 square miles.*

For convenience of reference it was decided to divide the gold fields into an Upper and Lower Field by a line running due east and west along the northern boundary of Chilton, Coosa, Tallapoosa and Chambers. To that part of the Field lying south of this line the name "Lower Alabama Gold Belt" was given, and it thus comprises the counties of Coosa, Tallapoosa and Chambers and part of Chilton and contains about 1700 square miles. To that part of the Field lying north of this line the name "Upper Alabama Gold Belt" was given. It thus comprises the counties of Cleburne, Clay and Randolph and part of Talladega, and contains about 1800 square miles. It was further decided to spend three months in each Belt. The work on the Lower Belt was progressing very well when I received word that my wife was very ill at home. This necessitated my presence there and I suspended the examination about the middle of August, 1891, after one months work, and was unable to resume it during the remainder of the year. This report is therefore incomplete even as regards the Lower Belt and is to be considered merely as a preliminary report. It was thought best to publish it in its present shape instead of waiting another year for its completion and to incorporate some additional information concerning this Belt with the report on the Upper Belt, to be published in 1893, if not sooner.

Some photographs of very interesting localities in Chilton and Coosa counties were taken, but, most unfortunately, the box containing the plates was broken in transit and the plates were lost. They represented views at the Rippatoe Mine, Alum Bluff and the neighborhood of Higgins Ferry across the Coosa River.

It is hoped to embellish the next report with numerous photographs of the principal gold bearing localities of both belts, and especially of Hog Mt, the Ulrich and Jones Pits, Silver Hill, Gregory

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*The total area of the crystalline rocks is 4425 sq. miles. E. A. Smith, Agric. Rep. 1881-2.

Hill, Blue Hill, the Devil's Backbone and other places belonging to the Lower Belt.

I desire to express my thanks to Prof. John M. Francis, of the University of Alabama, for much valuable assistance in the assaying of the samples; to Mr. E. E. Newton, a recent graduate of the Scientific Department of the University for aid in the field as volunteer assistant; to Major Jno. L. Harrell for the pleasure and profit of his company through many parts of Chilton county; and to Col. B. L. Dean for many kindnesses in Tallapoosa county.

WILLIAM B. PHILLIPS.

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THE GOLD FIELDS OF ALABAMA.

General Description.

The Gold Fields of Alabama extend in part or wholly over the counties of Cleburne, Talladega, Randolph, Clay, Tallapoosa, Chambers, Coosa, Elmore and Chilton. The occurrence of the Gold is therefore confined to that portion of the State in which extensive areas of the crystalline rocks appear. It is not the purpose of this report to consider whether these rocks belong to the Archæan or to the Lower Silurian, whether they are orignal primitive rocks or the products of a more or less complete metamorphism. Probably the western edge of the Field is of Silurian Age, but it seems to me that the inner portion and especially the Eastern part are of older date. One might go so far as to say that if the rocks in the central and western part of North Carolina, and in the Northwestern parts of South Carolina and Georgia are of Archæan Age, then these rocks are, for there is the closest relationship between them, both from a stratigraphic and petrographic point of view. The Gold bearing rocks of Alabama are of the same age as the gold bearing rocks of North Carolina, South Carolina and Georgia, whatever this may be. The occurrence of large deposits of graphite might lead one to classify them as of a period when there was at least plant life on the earth, but, on the contrary the entire absence of fossils and other evidences of life, if we except graphite, would incline one to project their age beyond that of the Silurian. A long and careful examination of the district with especial reference to the stratigraphical relations of these rocks towards the Silurian rocks of the western edge and towards each other would have to precede a positive opinion.

The productive portion of the field is comprised within the following limits: From Calera, on the Louisville and Nashville Railway, thirty miles south of Birmingham, draw a line in a north easterly direction to Tallapoosa, Georgia, on the Georgia Pacific Railway. From the same point draw a line in a south easterly direction to Columbus, Georgia. We have thus, roughly speaking, an equilateral triangle of ninety miles on the side and the area will be about 3,500 square miles. I have used the expression "productive area" to imply that portion of the State in which gold mining has at some time or other been carried on with success. It is not to be taken as meaning that gold mining is now prosecuted within this area on an extensive scale, for such is not the case.

Within this area of 3,500 square miles the metamorphic and primitive rocks find their greatest development and form the south western termination of the great Alleghany Range, or, as it should perhaps be termed, the Appalachian Range.

The country rocks are for the most part crystalline schists and slates, talcose, micaceous, and graphitic, deeply buried on the south western edge beneath the clays of the Tuscaloosa Formation (Cretaceous) but outcropping with ever increasing boldness towards the east until in Coosa county, and farther east they appear with a very coarse granite in considerable hills and bluffs. The first appearance of the granite is in Coosa county near the town of Rockford; from this point to the east it occurs with marked frequency interstratified with graphitic schists and slates and imparting to the landscape quite a bold and rugged appearance.

CHILTON COUNTY.

HONEYCUTT'S MILL.

The most westerly exposure of the crystalline schists which I was able to observe is near Honeycutt's Mill in the western part of Chilton county, Sec. 17, T. 22, R. 13, E, 13 miles from Clanton, on Mulberry creek. At this place the creek has cut its way down through the overlying clays of the Tuscaloosa Formation and the underlying rock is well exposed. It is a greenish and bluish green slate, in places quite hard and crystalline. It strikes in a general north east course (N. 75E. near the mill) and dips 15 to 20 degrees south east. The bed of the creek is 125 feet below the general level of the country. In places the slate is soft and rotten, breaks down readily and gives a stiff reddish soil.* It frequently carries small veins of quartz, from one-half an inch to eight inches in thickness running parallel to the slate. It would appear that many of these quartz seams, formerly carried pyrite, for there are evident traces of this mineral still to be found, with now and then a fairly good piece but partially decomposed. As a rule, however, the pyrite has disappeared, the quartz is cellular and, for the most part, barren, showing neither gold nor pyrite. It is noticeable that wherever the slate carries quartz it is harder and more crystalline than when the quartz is absent.

Placer mining has been carried on along this creek in a very small way for the last fifty years, beginning about two miles below the mill and extending about eight miles up the creek.

Along the little branches that make into the creek I panned thirty pans, finding gold in twenty-five and failing to find it in five. The gold is held in a mottled red and white clay, sandy and carrying angular fragments of quartz. This clay is underlaid by a stiff white clay devoid of gold. It is exposed in the bottom of the branches and is overlaid by from 4 to 6 feet of soil and reddish clay, free of gold. In every pan there was left at the last a heavy black sand, sprinkled with minute fragments of garnets and clear quartz. The thickness of the gold bearing stratum is from one to two feet.

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*Limonite (brown iron ore) occurs on the waters of Mulberry creek above Honeycutt's, in considerable masses.

The origin of the gold here is to be sought in the thin seams of quartz (formerly pyritous) between the layers of slate. The gold content of the pyritous quartz has been distributed in the clays resulting from the decomposition of the slates.

I remark here

1. No gold has been found in the soft slates which are free of gravel.

2. The quartz seams themselves show free gold in the pan now and then.

3. The clays resulting from the decomposition of the slates are of two sorts, a soft smooth clay with no gravel and no gold, and a sandy, gravelly clay with many angular pieces of quartz and half decomposed pyrite, carrying free gold.

4. The unfailing association of the gold with black iron sand and quartz, with occasional fragments of pyrite, points to the pyritous quartz seams as the origin of the gold.

Although gold is to be found in nearly every little branch running into Mulberry Creek, in the vicinity of Honeycutt's mill, yet I do not think that it occurs in sufficient quantities to warrant any further investigation. The gravel in which it is found is not continuous nor is it rich enough at any place that was examined for it, to be considered more than an interesting distribution of the metal. This is the most western point at which gold has been found in situ, and its association with quartz and pyrite is but another proof of the close companionship of these minerals in the Southern gold fields.

Between Honeycutt's Mill and Clanton I observed no exposure of the underlying rocks; they are doubtless overlaid by the Tuscaloosa clays which extend in an unbroken sheet across the State from Tuscaloosa to the south-east, obscuring the crystalline rocks entirely except where some stream has cut its way through.

On the west side of the Louisville and Nashville Railway the crystalline rocks are but seldom seen, as I went carefully over that part of Chilton County almost to the Autauga line without seeing any sign of them at all. None of the wells dug in that part of the county have penetrated to the old rocks, although some of them have been sunk through forty and fifty feet of soil and clay. The Tuscaloosa clays must be more than one hundred feet in thickness in this part of the State, in certain localities doubtless nearer two hundred feet than one hundred. No gold is to be found in that part of Chilton County below Clanton and on the west of the L. & N. R'y, which demands a more detailed examination. Near Verbena, a station on the Railway below Clanton, some prospecting for gold was carried on many years ago, but no evidence could be found that it was profitable or even encouraging. Some isolated placer washings may still be heard of but I do not think that we need pause to consider them. This part of the county is not to be regarded as a gold district, for, it is not until we reach the old Rippatoe Mines near the Coosa River that we come upon any sound basis for even a preliminary testing.

About one-half a mile north from Verbena, at the old Floyd Mill, there is a fine out crop of micaceous hornblende schist, tough and well crystallized. It strikes N. 50° E. and dips 15 degrees S. E. It is found also on the west side of the L. and N. R'y one mile S. W. of Verbena and there disappears beneath the clays.

WILLIAM HOWARD'S.

In the S. W. ¼ of Sec. 29, T. 21, R. 16 E., Chilton County, at Wm. Howard's, there is a good exposure of quartz interstratified with clay slate. It is of the sugary variety, very white and granular. A sample taken from a vein of eight inches thickness at Howard's gate gave in gold $6.20. A vein of similar appearance, however, at Tom Howard's in Sec. 29, T. 21, R. 16 E., gave only $2.06 per ton.

ROCKY CREEK.

On Rocky Creek, in Sec. 30, T. 21, R. 16 E., Chilton county, two miles east of Verbena, extensive washings for gold have been carried on in the gravel. Heavy ledges of a dark, fine grained hornblende schist, carrying biotite, cross the creek, bearing N. 15° E. and dipping 20 degrees to the S. E. These schists enclose bands of quartz, in places somewhat pyritous, which are rarely of greater thickness than a few inches. In the immediate vicinity of the quartz seams the schists are harder and more crystalline. The gold gravel underlies the soil at depths varying from 3 to 6 feet and extends on both sides of the creek for about one hundred yards. It is rarely more than twelve inches in thickness and is composed of rounded peices of reddish quartz from one-half inch diameter to six inches. The pay gravel lies on a greenish clay slate. Rocky Creek runs in a general N. E. course and the quartz seems bear in the same direction. The shifting of the creek bed from side to side has doubtless distributed the gold gravel over the area mentioned.

William Howard, an experienced gravel washer of the vicinity, told me that in about ten weeks he himself had obtained $200 worth of gold along Rocky Creek; in one day securing $19, The only apparatus used was the pick and pan. This was twenty years ago. Per contra, he says that a few years ago a stray miner worked there two months and got only $60.

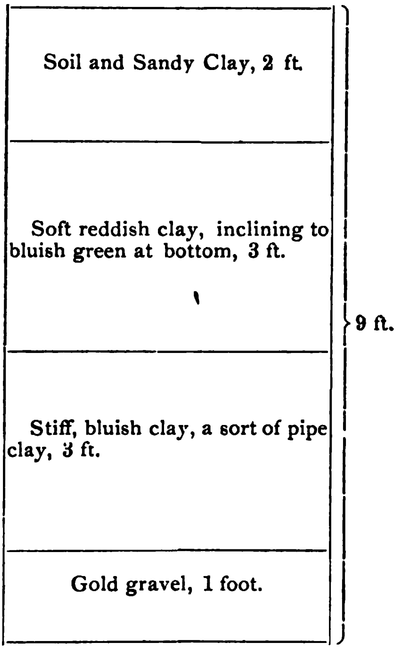
Rocky Creek would not afford sufficient water for extensive operations, and, besides the pay gravel appears to have been pretty well worked over. A considerable amount of work has been done along the Creek from first to last, but none within the last twenty years. Most of the work was done before 1860, when through this part of the State there was much interest shown in gold mines and especially in placer mines. I saw no evidence of the existence of a workable seam of quartz on Rocky Creek near the old workings. At Howard's there is a better prospect for quartz mining than on Rocky Creek, for the existence of gold bearing sugary quartz at Wm. Hôward's is an encouraging sign. It does not seem to me that Rocky Creek will afford pay gravel in sufficient amount and of sufficient richness to warrant any extensive investigations. Doubtless a considerable amount of gold was obtained along the creek fifty years ago with the simple appliances then in use, such as the pan, cradle, and Long Tom. The best of it has, however, been thoroughly worked so that it is now difficult to find a place from which good panning can be had.

THE RIPPATOE MINE.

This famous property is situated in Sec. 17, T. 21, R. 16 E., Chilton County. It was extensively worked prior to 1860, work having been begun here as early as 1835 and continued with but little interruption for twenty-five years. By far the greater amount of placer mining carried on west of the Coosa River has been done at this place.

The gravel lies on both sides of Blue Creek and is of the same nature as the Rocky Creek gravel. For a mile up the creek from Jas. Mims's, on both sides, there are innumerable old pits, trenches and ditches. These are now so fallen in that I had to sink two new pits in order to examine the gravel at all. Following is a vertieal section of a pit in the bottom of which we came upon a layer of auriferous gravel, very poor but of the same character as the richer gravel, as I was informed by Wm. Howard:

Vertical Section to Gravel, Rippatoe Mines.


Soil and Sandy Clay, 2 ft.
Soft reddish clay, inclining to bluish green at bottom, 3 ft.
Stiff, bluish clay, a sort of pipe clay, 3 ft.
Gold gravel, 1 foot.
9 ft.

The gravel is imbedded in a reddish clay, at times somewhat indurated, but generally of a loosely compacted nature, yielding readily to the pick and shovel. From Wm. Howard and others who worked at these diggings I ascertained that the gravel was generally not less than six feet beneath the surface, varying from this depth to eight and even nine feet. As the deposit neared the adjacent hills the gold became scarcer and the gravel thinner and at greater depth.

A great deal of the gold obtained was found in the run of the creek, caught against upturned edges of the slate. Several pieces of gold valued at $1, $5, one valued at $20 and one at $70 were found at these diggings. It is impossible at this time to give any reliable estimate of the amount of gold obtained at the Rippatoe. An approximate statement could be given if it were known what the average yield of gold per bushel of gravel was, for it could be calculated how much gravel was removed. But there are no statistics and no reliable sources of information. The property was not worked by a regularly organized company, the different gangs of men were associated together for the more economical treatment of the gravel, they kept no permanent accounts, disbanding when they pleased and each going its own way without regard to the others. From first to last, however, there must have been a large amount of gold removed. The extent of the old workings proves that, for in those days when the miners did not find pay gravel they quit and went to some other place. It was not the custom to spend either time or money in prospecting on such an elaborate scale. There was enough water in the creek for their purposes, although not enough for a large business, and they kept at work in a small way for many years, accomplishing in the twenty-five years an astonishing amount. When the California gold fever came upon the country most of these miners were attacked by it and started for that Eldorado forthwith, and there has been no gold washing in this vicinity worthy of mention since 1855.

Only one placer mining company is now at work in the State, the Arbacoochee, in Cleburne Co. I have not visited the place, but understand that of late a better gravel has been found and that the operators are hopeful of good profits. Cleburne County belongs to the Upper Gold Belt and I have not yet visited that part of the State, and can not therefore speak of my own personal observation. But so far as concerns the old placer mines of the Lower Belt, lower Chilton, Coosa and Tallapoosa Counties, I do not think that any revival of the industry is likely to take place. The best gravel has been worked over as with a comb and nothing remains now that would attract capital, for it requires a large amount of money to operate such washings on a profitable scale.

At the Rippatoe the gold was derived from the small quartz veins lying between and in micaceous hornblende schists and clay slates. The creek has cut its way down through the schists and slates, undermining the quartz seams and distributing the resulting gravel along its course. The average width of the valley along which the gravel is found is less than two hundred yards, in linear extent three quarters of a mile. The relation of the gold gravel to the country rocks appears to be as follows:

The schists themselves are pyritous and also enclose small seams of pyritous quartz. They lie to the Eastward of the clay slates. The slates are softer and more easily broken down by atmospheric agencies and by running water. The schists, overlying the slates, are in this way undermined and finally give down more or less, and allow their quartz seams to be distributed as gravel along the bed of the creek. This result is accelerated by the occurrence of thin seams of pyrite between the quartz and the schists. In places the schists are so impregnated with pyrite that it can be seen plainly with the naked eye. In other places they present the appearance of a true gossan. On panning there is always left in the pan a mixture of black iron sand with small fragments of clear quartz, garnets and pyrite more or less decomposed.

The tendency of the clay slates in this part of the county to present the appearance of a gossan is shown on quite a large scale on the road from Verbena to Higgins' Ferry about one and one-quarter miles from the Rippatoe Mines. At this place a large seam of brown iron ore crosses the road and can be traced for several miles in a N. E. and S. W. direction. Some samples of the ore are very good and the outcrop is bold. There may be enough of this ore above water level to justify a development shaft or drift; it would appear that is is derived from the infiltration of ferruginous waters obtaining their iron from the oxidation of pyrite. I observed numerous cavities of pyrite crystals in the accompanying quartz. Several years ago the Sloss Iron and Steel Co. of Birmingham opened a deposit of this ore lying four miles north of this place, but abandoned the undertaking after going to considerable expense in the construction of a branch road from the L. and N. Ry. It may be, however, that the lower part of the deposit near Rippatoe is of better quality and in greater quantity.

On the land of James Mims in Sec. 16 is to be seen the same kind of gravel accompanied by the same ferruginous slates as appear on the Rippatoe property. Here also the gold gravel has been thoroughly worked over, and although a considerable amount of gold was obtained prior to 1860, nothing of consequence has been done since. I sampled a small seam of sugary quartz on the Rippatoe place near Tiernan's house below James Mims' and found it to contain, in gold, $2.06 per ton. The gravel washings at the Rippatoe have been practically exhausted, but it is probable that by careful investigation workable quartz could be found. The owners of the land should have it examined with this purpose, and I would recommend that they examine especially the western part of the property towards the upper waters of Blue Creek, for as one approaches the Coosa River the schists become much coarser and the dip rises. I observed neither gneiss nor granite on the west side of Coosa River in this part of Chilton County, but it is quite noticeable that the granitic and gneissic soils begin to appear in Sec. 15, T. 22, R. 16 E. In this section also on the land of Jackson Mims numerous pieces of magnetic iron ore have been picked up on the surface. Mr. Mims has prospected for the vein with drift and shaft, but has not yet come upon it. The magnetite is associated with a coarse hornblende schist carrying mica and garnets. No gold has been found in connection with it, nor in fact has gold been found on Blue Creek below the Rippatoe place.

Between the Rippatoe and Higgins' Ferry, about one half mile from the ferry gate, there crosses the road a seam of iron ore partly limonitic and partly of higher oxidation. It appears to have been derived from the oxidation of pyrite and the infiltration of iron-holding waters. The remains of pyrite crystals are to be seen in the associated quartz. The seam can be traced for a quarter of a mile, but does not show any reliable indication of increased richness. A similar ore is to be found in Coosa County also as in Sec. 31, T. 23, R. 20 E. and in Sec. 1, T. 22, R. 19, and in Sec. 6, T. 23, R. 19, where it is partly converted into magnetite.

It is not likely that extensive deposits of good ore will be found where the evidences of the recent oxidation of pyrite are so numerous and so unmistakable. The limonites of S. E. Chilton and the middle and Southern Coosa are comparatively of recent origin. The rocks in which they occur are clay slates and micaceous graphitic schists more or less impregnated with pyrite. The rocks themselves may be, and doubtless are, of the Archaean Age, but the iron ore is of far more recent production, resulting, as it has, from the atmospheric decomposition of pre-existing beds and stringers of sulphuret of iron. Where the original amount of pyrite was very great or where local causes have led to a concentration of the iron these secondary ores are of value, but I can not speak hopefully of these ores. They do not seem to me to exist in sufficient quantity for commercial purposes.

COOSA COUNTY.

ALUM BLUFF.

The name Alum Bluff is given to a bold mass of micaceous schist and quartz rising to the height of 250 feet above Hatchet Creek, near its mouth, in Sec. 35, T. 22, R. 16 E., Coosa county. The schists are in places impregnated with the sulphates of iron and aluminum arising from the action of the sulphuric acid derived from the oxidation of pyrite. The so-called Alum forms a white incrustation on the surface of the bluff, and after a long drouth can be scraped up by the handful. It occurs most plentifully near the top of the bluff opposite a large pine tree standing some 200 feet above the creek. At this place there appears a heavy seam of bluish crystalline quartz carrying decomposed pyrite. It is eight feet in width, strikes N. 30 deg. E. and dips also with the schist S. E. 40 degrees. A sample gave to Lagerfelt and Mills, Birmingham, Gold 0.60 ounce per ton, silver, trace and was therefore worth $15.40 per ton. A sample of the walling next the quartz gave in gold, 0.35 ounce and silver 0.10 ounce per ton and was therefore worth $7.33 per ton.

The quartz is somewhat cellular and the sulphurets for the most part pretty well decomposed. This is probably a true vein and is well worth further examination. I did not observe it elsewhere in the immediate vicinity, as it lies in such a position as to be easily covered by the decomposing schists. The seam could be easily mined, as it stands well above Hatchet Creek and the upper two hundred feet of workings would be self draining. I was unable to ascertain the owner of the property, although I made diligent inquiry of well informed persons.

GOLD MINE RIDGE.

Secs. 1 and 2, T. 21, R. 16 E., Coosa Co.

Van Zandt and Smith prospected for copper and gold on this ridge in 1855, and Col. George and Jas. L. Tait for copper and graphite in 1872 and 1873.

The ore is quartz held in a micaceous schist and carries graphite and pyrite. I secured a sample from a four foot seam and it gave to Lagerfelt and Mills, gold 0.15 ounce and silver 0.25 ounce per ton and was therefore worth $3.35 per ton. A considerable amount of work has been done here, but all of the old pits, trenches, &c., have fallen in and nothing can be seen of the seam underground. I saw no evidences of the existence of copper in paying quantities, and the ore is too poor in gold to work for this metal under present conditions.

FLINT HILL.

Sec. 17, T. 22, R. 16 E., Coosa Co.

Heavy seams of crystalline quartz occur here in talcose schist. Of four samples taken only one showed more than a trace of gold and this one contained $4.13 per ton.

Flint Hill is about two miles above Wm. Hardy's Mill on Weoguffka Creek. At the foot of the hill coming towards Hardy's Mill there is found a heavy ledge of talco-micaceous schist carrying graphite and pyrite. These two minerals are so closely associated in the same rock as to give it a very odd appearance. Upon fire assay, however, I found no more than a trace of gold and silver.

In this part of the county many people have sought for a valuable silver mine said to have been worked by the Indians, but concealed by them, so that no one can find it. According to current opinion, the mine is extremely rich, having furnished the Indians with untold wealth for generations. When they left the county, some sixty years ago, they sealed up the entrance to the mine with heavy rocks and then obliterated all traces of the approaches to it. This was very unkind, for they had no reasonable expectation of returning to Coosa County, and could just as well as not have told where the mine was and how they obtained the ore. I am inclined to think that if the Indians mined silver in this part of Coosa County they had first to convey the ore there from some other locality, an operation by no means unheard of, it is true, but in this case hard to believe.

I have to thank Mr. R. C. Hardy, Dollar P. O., for many courtesies, especially in pointing out to me one of the late Wm. Gessner's Tin Mines. This is situated in the S. W. Sec. 24, T. 22, R. 16 E. Some excavations have been made here, and Mr. Hardy informed me that from the ore obtained Gessner got 3.50 per cent of tin. Mr. Hardy said that he was with Mr. Gessner when he took the samples and he gave me a piece of the ore from which it is said 3.50 per cent of tin was obtained.

The ore is a close grained, much distorted quartz veinlets bound in hydro-mica talcoid schist. No extensive investigation has been made at this place.

During my stay in this part of Coosa County I was the recipient of many kindnesses from Mr. Frank Higgins, who owns the Higgins Ferry and a great deal of the best land along the river contiguous to the Ferry. I desire to express here my obligations to him and the various members of his family. It is always a pleasure to meet wide awake, intelligent men who are interested in the development of the country.

The photograps taken in Chilton County and in this part of Coosa County were unfortunately lost in shipment to Tuscaloosa, so that no views can be given of the Rippatoe or the Alum Bluff.

ROCKFORD.

Between Higgins' Ferry and Rockford, the county seat of Coosa County. one sees the same schists and slates as occur on the west stde of Coosa River, but the dip is steeper and the texture coarser. About two and a half miles from Rockford there are found for the first time ledges of a very coarse, friable graphite, having the same course as the country rock and approximately the same dip. They alternate with the schists and slates and extend to the south western part of Coosa County, where they cross the river and are found at and near Wetumpka, assuming here, as also toward the north east part of the county, a closer grain and firmer texture. At Goodwater, a station on the Columbus and Western Railway, in the north east part of the county, the granite becomes much harder and is suitable for building purposes. Lying in immediate proximity to the granite towards the east there occur ledges of a coarse graphitic schists carrying thin seams of quartz and pyrite, and conforming in dip and strike to the contiguous rocks. At times these quartz seams become quite large, as in the W. ½ S. W. ¼ Sec. 14, T. 22, R. 18, one and a half miles west of Rockford, where one of ten feet in width may be seen between two ledges of granite. This quartz carries tourmaline and tantalite, considerable fragments of this latter mineral having been found on the surface of the ground during the last ten years. A piece weighing 16 ounces, now in the Geological Museum at the University of Alabama, was obtained here besides many smaller pieces. It occurs in scattered fragments and occasionally imbedded in quartz.

(For Prof. Tuomey's description of the metamorphic rocks and the granite of Coosa County, see Appendix C.)

In immediate association with a ledge of coarse granite, a quarter of a mile north east of the tantalite locality, I picked up from the surface of the ground nearly two pounds of Cassiterite, the oxide of tin, some of the crystals measuring half an inch across the face and exhibiting an excellent crystallization. Dr. Eugene A. Smith, State Geologist, was the first to examine this locality for tin, which he did in or about 1880. In 1884 Hon. John S. Bentley, Probate Judge in Coosa County for 18 years, sent a box of minerals from Coosa County to the elder Dr. Chas. Shepard, in which were some crystals he thought were cassiterite. In his reply Dr. Shepard told him to look out for tin. In the American Journal of Science for 1884 will be found a brief mention of the matter. Here, however, it rested. No one had examined the place critically, and it seems to have been forgotten that tin had been found there. The honor of the discovery belongs to Dr. Smith. The only share I have in the matter is the further identification of the crystals as cassiterite and the securing of the largest quantity of tin ore as yet obtained in this State, about two pounds of pure crystals. I say pure crystals, for I sent a sample to A. R. Ledoux & Co., 9 Cliff St., N. Y., for analysis, while I was still in the field, and received a report from the firm that the crystals contained 78.19 per cent. of tin, theory requiring 78.68 per cent.

Investigations are now being conducted in this locality, and it is hoped that before long some interesting results will be reached. My attention was drawn to the matter first by Judge Bentley, whom I visited at his house near Rockford, Aug. 4th, 1891, and again on Aug. 13th and 14th. He told me of the occurrence of tin ore on his land and I examined the place August 5th, and again on the 14th with his son, William H. Bentley, the Judge at that time being unable to walk, having been stricken with paralysis in 1887. For more than twenty years he had been a most indefatigable investigator of the mineral wealth of the county, and indeed while I was there, although he could not take a single step nor help himself into and out of his chair, he had his servant to place him in his buggy and went with me over a considerable part of the district.

Judge Bentley was a remarkable man; always alive to the best interests of the county, popular with all classes of citizens. His untimely death, which occurred in January, 1892, removed from Coosa County one of the best of men as also one of closest observers of natural phenomena I have ever had the privilege of knowing. I can not allow this opportunity to pass without expressing sincere regret that he was taken away at this time, although such a digression may appear out of place in a report of this nature. The State can ill afford to lose such men.

In the same section with the tantalite and cassiterrite i. e. Sec. 14, T. 22, R. 18, on Judge Bentley's land, is found an outcrop of brown iron ore. It shows three feet of fair ore in a trench across the strike, but does not appear extensive enough to warrant hopes of a workable deposit. It seems to be merely a gossan, as the inclosing slates are in many places impregnated with pyrite in various stages of decomposition.

In the bed of the Gin-house branch, as also in the Carroll and Pole branches, contiguous to this locality, gold has been obtained by washing. The gold is derived from the quartz seams held in the slates and is now associated with the gravel resulting from the breaking down and distribution of the quartz. I do not think that the gravel is worthy of any extensive examination, although it may be that some of the quartz seams carry enough gold to warrant investigation.

Almost within the limits of the town of Rockford is an old pit sunk forty or fifty years since for gold. The ore is quartz, walled in slate, strike N. 3° E., dip S. E. 40, width of seam 6 feet. A sample taken from the old dump gave on fire assay:

No. 1311.	Gold............	6-10 oz	Value per ton, $12 40.
	Silver...........	2-10 oz.	

It was worked several years ago by Mr. Lewis Parsons, of Birmingham, with but little success so far as could be learned. When first opened the ore was roughly crushed and washed at a small stream near by with some profit. It is often the case that such seams near the surface, where atmospheric agencies have been at work for ages, will yield enough gold by the simplest processes to pay for the labor and give more or less of a profit besides. But as the ore becomes harder, and more especially when sulphurets begin to appear, as is almost universally the case, the crude methods of fifty years since will not suffice. This is the main reason why so many abandoned pits, shafts, &c., are to be seen in all parts of the gold belt.

Near Hissop postoffice, on the land of F. M. Darsey, I observed a close grained granite in association with a highly metamorphosed clay slate, in Sec. 14, T. 22, R. 19, Coosa County. Mr. Darsey afterwards sent me a sample of cellular quartz from near this place but it contained only $2.06 in gold per ton.*

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*Fair crystals of Beryl are found near Hissop.

On the land of E. M. Thomas (Hissop P. O.) in Sec. 11, T. 22, R. 19, is a heavy ledge of a highly graphitic schist inclosed between walls of coarse granite. Mr. Thomas informed me that a few years ago he roasted and smelted some of this schist in a black-smith's forge and obtained from one pound of the rock 35 cents worth of silver. This silver he had made into a collar button and, as proof that the rock contained silver and that he had extracted it, he exhibited the button. I took samples of the schist from the same spot which was said to have yielded the silver but on fire assay it failed to show more than the merest trace of gold, with no silver. As the schist is pyritous the gold may be contained in the pyrite, but certainly it is difficult to believe that from this rock any one had obtained silver on the scale of $700 per ton. From near the same locality I took a sample of bluish-green mud which Mr. Thomas also assured me contained silver, as he had himself run it out. On fire assay it gave the merest trace of metal.

On the land of Harris McKinney, in Sec. 6, T. 23, R. 19, and also in Sec. 1, T. 22, R. 19, Coosa County, there is said to occur a seam of magnetite. I examined the same seam in Sec. 31, T. 23, R. 19, at Mr. McKinney's house, where small peices of a slightly magnetic brown ore are found on the surface, but I am not of the opinion that magnetite in any quantity will be found in the vicinity. The ore is derived from the oxidation of local seams of pyrite in the schists and slates and even now pyrite may be observed in immediate proximity to the ore. I obtained at Mr. McKinney's house a peice of sugary quartz representing a seam said to be on his land. On assay, however, it gave:

No. 1309. {Gold..........2-10 oz. / Silver.........trace.} Value per ton, $4 13.

The road from Rockford to Kellyton runs for 14 miles in a course a little N. of E. Many ledges of coarse granite are crossed, alternating with bands of slate and graphitic schist carrying in places evident signs of pyrite. This mineral seems to have been pretty well distributed in these slates and schists, almost any peice of rock which has not suffered atmospheric decomposition will exhibit small crystals of pyrite. In certain localities where the pyrite was to some extent concentrated and where it has been decomposed there will be found fair indications of brown ore. I have seen seams of three feet and more in thickness and apparently indicative of a workable deposit. While pyritous quartz and even pyritous slates do, in some places, suffer so great a decomposition as to allow of the utilization of the residual oxide of iron, yet I do not think that the seams of brown ore in this part of Coosa County will be found to be of this kind. The same opinion has already been expressed as to the brown ore of south-east Chilton, for while the amount of visible ore there is far greater than in any part of Coosa County visited, still it has been derived from the enclosing slates in the same manner and is, in my opinion merely the residue of probably much more extensive seams now removed by erosion. I would not be understood as saying that ores derived from the enclosing rocks are, per se, and for this very reason unreliable. The elaborate and most conclusive researches of Sandberger, von Cotta and others have long since established that many of the most valuable ores are thus derived, notably the ores of the precious metals. But there are ores and ores, conditions of enclosure favorable to richness and conditions unfavorable, and it seems to me that in the case of all the brown ores mentioned in this report, we have the latter set of conditions. I am aware that this view of some of these brown ores is not held by some men whose opinions are worthy of consideration, but an acquantance with the brown ores of this State, North Carolina and Kentucky warrants me in taking the position occupied.

It was hoped that during the progress of the survey some indications of the existence of workable iron ore would be found in this part of Coosa County; that is, from the Coosa River through Rockford to the line of the Columbus and Western Railway; but none were found, although to the eastward of Rockford three lines of investigation were carried on. One from Rockford to Kellyton along the mail route, one from Rockford to Alexander City by the lower road, and one to the south east part of the county in the vicinity of Equality P. O. and beyond into Elmore County four miles. This last named examination was conducted by Mr. E. E. Newton, a recent graduate of the University of Alabama, who was with me as a volunteer assistant. Not only were no iron ores of any importance found, but with the exception of the Alum Bluff and the Rockford Mine, the quartz examined yielded mere traces of gold and silver.* In my opinion, the more northern portions of Coosa County will probably be much more productive of gold ores than the middle and southern portions. (See appendix C.) It was my intention to return through this part of the county later in the summer and to remain there for some time, but the serious illness of a member of my family compelled me to abandon the survey before this could be done.

That portion of Chilton County lying north of Clanton and east of the Louisville and Nashville Railway, was also to have been examined later in the summer, but for the same reason had to be left to some future survey. This report is to be taken as a reconnoissance of the Lower Gold Fields, to mark out those portions of the Field that are worthy of a more extended examination, so that in the future the energies of the Corps should be spent upon ores that can be worked at a profit. That such do exist in this

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*No. 1,325. Reddish crystalline quartz, showing free Sulphur from land of Mrs. Nancy Bryant, Sec. 29, T. 21, R. 20, Coosa County.
Gold...... } Traces.
Silver..... }

No. 1326. Sugary quartz, Equality P. O., Sec. 31, T. 21, R. 20, Coosa County.
Gold...... } Traces.
Silver..... }

No. 1327. Sugary quartz, Sec. 18, T. 22, R. 17, Coosa County.
Gold—1-10 oz. per ton.
Silver—trace. Value per ton, $2 06.

No. 1328. Sugary quartz, Sec. 28, T. 25, R. 20, Coosa County.
Gold...... } Traces.
Silver..... }

Nos. 1,321 to 1,324, inclusive, are assays of reddish crystalline quartz, from the land of J. W. Willingham, in Sec. 10, T. 20, R. 4, Elmore County, but only one showed more than traces of gold and silver, and that one contained 1-10 oz. of gold per ton ; value per ton $2.06.

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Field is to my mind beyond question, and I think I know something of the conditions of gold mining along the Appalachian Range. It is my deliberate opinion that Alabama offers great inducements to the gold miner, and that capital judiciously invested and economically administered in the extraction of the precious metals would, in this State, find ample returns.

TALLAPOOSA COUNTY.

I propose now to discuss that part of the Lower Gold Field which seems to me to offer these inducements and to hold out these promises of profitable investment.

I refer to Tallapoosa County, long known, with Cleburne County, as the scene of the greatest development in gold mining to be met with in the State, a place famous among the placer miners and quartz crushers of fifty years ago, and which has yielded a large part of the gold credited to the Southern States between the years 1830–1850.

In the adventures of Captain Simon Suggs, written to describe the truly remarkable experiences of this truly remarkable person, Johnston Hooper incidentally mentions a circumstance which bears upon the history of the gold fever in this part of Alabama. The Captain had bargained for a certain piece of land belonging to a Creek widow. When the time for payment drew near he found himself without the necessary funds to complete the trade, a condition of affairs by no means uncommon with him. Other speculators desired the same piece of land, and offered the widow much more than the Captain had agreed to pay, but she steadfastly refused to deal with any one but with her friend, Captain Suggs. She was beset on every side, but nothing could be done. It was known to the others that the Captain had no funds, and they supposed that in the end he would be forced to say so, when they expected to come in for something good. The Captain disappeared from the Post for several days, and no one knew what had become of him, although he intimated that he was going to borrow some money from a friend. Finally when the widow seemed upon the point of concluding that he had left the country and was about to sell the land to some one else, he rode up, dismounted and joined the crowd with an enormous pair of saddle-bags on his arm, heavily laden. The speculators at once concluded that he had "struck it rich," as the saying was and is to this day; there was no telling, gold was plentiful then and many good nuggets had been found, and many a fifty pounds of ore that would pay for the land many times over. They at once came to terms and bought from him the coveted quarter section for two and a half times what he had agreed to pay for it. When the bargain had been firmly arranged and the money paid, he quietly threw out from the saddle-bags a lot of worthless rocks picked up along the road. All this happened in what was then Tallapoosa County about the year 1835, and illustrates in a striking manner the rage for speculation. The throwing open of much valuable land for settlement, consequent upon the removal of the Creek Nation, was responsible for much of it, but the genuine gold fever is to be credited with the greater part.

It is most unfortunate that no reliable statistics of the number of miners, or the yield of gold or the cost of the operations are now to be had, but from the trustworthy tradition and from what I have myself seen over a large part of the district in question, there can be no doubt of the activity that prevailed at that time among the gold miners in Alabama. It is said that in the adjoining county of Cleburne the town of Arbacoochee, now containing less than three hundred people, had in 1845 some five thousand inhabitants. From 1830 to 1850 the prospector was a familiar figure along the roads and among the hills of Tallapoosa.

GOLDVILLE BELT.

From Hillabee Bridge, six miles east of Alexander City, to and beyond Goldville for a distance of 14 miles, an almost unbroken line of pits, trenches and shafts bear witness to-day of the great amount of work done prior to 1855. A mere enumeration of some of these old workings, which may be seen and in part explored, even now will show to what extent these operations were conducted. Thus, from a point half a mile above the bridge to the Birdsong Pits beyond Goldville, we have

	Section,	Township,	Range.
Ulrich Pits	8	23	22
Mahan Pits	4	23	22
Croft Pits	34	24	22
Stone Pits	34	24	22
Ealy Pits	26	24	22
Log Pits (Tog Pits is incorrect.)	24	24	22
Houston Pits	18	24	23
Goldville	8	24	23
Germany Pits	8	24	23
Jones Pits	5	24	23
Birdsong Pits	4	24	23

These by no means exhaust the list; there are others which in their day were quite as well known and quite as productive, but whose exact location is now unknown.

It will be seen by consulting any map of Tallapoosa County, or the new State map, that these old workings follow each other in the order given from south west to north east. They do not appear upon either map, but by laying a straight edge along the map from Alexander City to Goldville, they will occur in almost a right line, the Ulrich Pits being the most southwesterly and the Birdsong the most northeasterly. Of the history of these mines little or nothing is known. The only mention of any of them which I have been able to find is a brief note by Oscar M. Lieber, in the Second Report on the Geological Exploration of the State of Alabama by M. Tuomey, published in 1858.

This Report[*] was posthumous, and was edited by J. W. Mallett, now the distinguished Professor of Chemistry in the University of Virginia. He says in his Preface that the Report was drawn up by Prof. Tuomey in November, 1855, and was presented to the State Legislature at its Session of 1855–56. The information it contains is therefore such as was available prior to 1855, although the Report was not printed until 1858. On page 64 of this Report Prof. Tuomey says of Goldville: "The gold mine of this place was discovered in 1842, and was worked to water level. The most noted portion of the mine was known as the tog pit." (There must be an error here, for Col. B. L. Dean, of Alexander City, who has known that district very well for thirty-five years, informed me that the name of 'tog pits' was entirely unknown there. Prof. Tuomey evidently referred to the Log Pits, which, however, are three miles south west of Goldville. W. B. P.) Prof. Tuomey continues: "the richest part of the vein in this pit (what he calls the tog pit) was from 4 inches to 2 feet thick. It was quartz in talcose slate, and yielded 2½dwts. to the bushel of ore. The gold was worth 90 cents to the dwt. Almost $30,000 worth of gold was extracted from this pit, and from this the proprietors received in addition $80.00 in silver. The history of this mine is like that of all Southern gold mines—the total want of any practical system of operations." This mine, Mr. Lieber reports, has been recently re-opened. "A vein has been discovered which, from its curious contortion, is called the snake vein. In the south side of the shaft it is poor, but in the northern side it yields on an average one dollar per bushel. The ore is a friable, porous, ferruginous quartz. The country is talcose slate, decomposed as far as yet reached. Numerous other veins appear on the same property, and properly managed success may be anticipated. The minerals found here, besides gold, are magnetic iron sand, native sulphur, garnets and mica." Thus far Prof. Tuomey.

As to the Ulrich Pits, it may be said that some forty or fifty years ago a German named Ulrich had a vineyard here and opened the gold pits. He mined and crushed in a crude way a considerable amount of the ore and is said to have made a good deal of money. The ore is a free milling sugary, and crystalline quartz, stained with oxide of iron, and held in a tough micaceous slate, strike North 30 deg. East, dip 40 deg. S. E. There are visible six seams of quartz, the largest six feet in width and the smallest three feet. They are separated by bands of slate, and the entire six seams are comprised within a distance of three hundred feet. They outcrop on a hill above Hillabee Creek, at elevations above the creek of fifty to one hundred and fifty feet. The 530 foot line of altitude runs at the base of the hill at the creek. The pits are now fallen in, as well as the drifts, but the nearest pit to the creek is distant three hundred feet. There is always a bountiful supply of good water in the creek and it never rises to the first opening. All of the work done was on the north side of the creek, for, although the creek cuts all of the seams, nothing has been done on the south side. Mr. Ulrich seems to have cut into the ore while excavating a wine cellar. The deepest pit was sunk fifty feet and is now fallen in and inaccessible in the lower levels. Several drifts were started in to cut the ore at depth and it was found to be of good quality. While a considerable amount of ore was taken out, from first to last, the main body was hardly touched, and there still remains a large amount of free milling quartz within one thousand feet of the creek. From several old dumps I secured samples of the ore which gave by fire assay from $2.06 to $8.46 per ton. (See table of assays along Goldville Belt, pp. 45 and 46).

One of the quartz seams on the Ulrich place crosses the Hillabee Bridge road about three miles from Alexander City, on what is known as the Duncan Place, one mile south west of the Ulrich Pits. Here it is 2½ feet thick, held in the same slate. A sample gave, by fire assay,

Gold .....2 10 oz. per ton.
Silver.................trace.
} Value per ton $4.13.

From this point this seam of quartz and others in close proximity extended in a north east direction for twelve miles to and beyond the Birdsong Pits. I have closely observed the character of the quartz over this distance and it differs but little from that at the Ulrich Pits. Scores of old pits, trenches and shafts are found. I do not think that any half mile between Duncan's and Birdsong's will fail to show evidences of former operations; some of them, for that day and time, quite extensive.

Over this entire distance of twelve miles the quartz seams are bold and strong, preserving the same general characteristics, and showing a remarkable continuity of walling, strike and dip. In places, as for instance at the Jones Pits, where the greater part of the old time work was done, they thicken up to thirty feet. Nothing of any moment has been done at any of the Pits for more than thirty years. Between 1835 and 1860, it is said that several thousand miners were at work along this range, but in 1850 they began to drift towards California, and this migration, with the disturbing effects of the civil war, put an end to the operations. A large amount was certainly taken out and treated, but with what results as to profits can not now be known. The country was then very thinly settled and all the supplies had to be hauled for 50, 60 and even 70 miles over roads that, for the most part, were simply execrable.

No records were kept of the amount of ore treated or the yield, and it would now be a hopeless task to endeavor to ascertain the out-put of gold or the cost of production. From a careful examination of the localities, the nature of the ore and the conditions under which the work must have gone on, it is, I think, evident that the operations must have been, in places, very profitable.

No organized capital was employed and there were no mills worthy of the name. But little was known of the art of mining, and still less of the art of milling, the most important consideration in the successful management of all gold ores, and there must have been a large loss of gold. Yet the work went on for years, some of it costly work. The only explosive they had was black powder; all of the drilling was done by hand and a great deal of the crushing also. But they kept at it, and the engineer who examines the district to-day can see for himself that an astonishing amount of ore was raised and treated. The old openings are now abandoned, large trees are growing in the pits and trenches and the shafts, some of them more than fifty feet deep, are gradually filling up with leaves, rotten timbers and debris from the walls. Gold mining in the Goldville District is unkempt, ragged and down at the heels.

At Goldville itself, between 1840 and 1850, there are said to have been fourteen large stores with a contributory population of at least 3,000. Now one looks in vain for the tenth part of this population, and the stores have been converted into dwellings and barns.

It must, however, be distinctly stated that the mining operations conducted forty and fifty years ago along this belt merely scratched the great deposits of free milling quartz that characterize it.

Above water level, i. e., at depts varying from 10 to 40 feet, these seams furnished a material much more friable and easily crushed than was found at greater depths. The gold was coarser, and the absence of any considerable amount of sulphurets allowed free malgamation. At few places along the belt, for a distance of 10 miles, did these old miners, so far as could be ascertained, penetrate to the the lower limit ot the decomposed sulphuret. At one place only did I observe the presence of undecomposed and decomposing sulphuret, viz: at the Jones pits, in Sec. 5, T. 24, R. 23, near the north east extremity of the Goldville Belt. Here the undecomposed sulphuret of iron, with arsenopyrite, began to come in at the the bottom of a shaft 60 feet deep. It is held in a hard, bluish quartz showing also free gold. A sample, which showed no free gold, gave by fire assay,

Gold......2 7-10 oz. per ton. } Value per ton $55.90.
Silver.....1-10 " " " }
(See also page 48.)

It is highly probable, and, in the light of universal experience in the South Atlantic Gold Fields, even certain, that the free milling ores, that is, such ores as readily yield their gold to mercury, begin to carry sulphurets below water level. As these come in the free gold goes out, and when a typical sulphuret ore is found, it contains about one third of its total gold in such a condition as that quicksilver will attack it. The other two-thirds can not be extracted with quicksilver at all unless the ore is thoroughly roasted, and even then incompletely. Forty years ago such an ore was almost worthless in a district affording no smelting ores. To be available at all it had to contain sufficient free gold, easily taken up by quicksilver, to pay for the mining and treatment of the whole amount of ore and leave something over for profit.

Gold exists in quartz seams in at least two conditions. First, as free gold, more or less fine and intimately mixed with the quartz. Second, combined, or mixed, with a mineral consisting of iron and sulphur, or iron, copper and sulphur, known as Pyrite, or Chalcopyrite. Generally the mineral occurring with the gold is pyrite, or, as it is briefly termed, sulphuret, meaning a compound of iron and sulphur. This sometimes contains copper, but in the Southern States rarely beyond two per cent. When this sulphuret is exposed to the atmosphere it begins to decompose, the product being oxide of iron, a reddish or reddish-brown substance, which remains, and sulphate of iron (copperas) which, being soluble in water, is washed away.

All the quartz seams of the Goldville Belt seem at one time to have carried sulphuret disseminated through the quartz. The sulphuret has been decomposed down to water level, so that now these seams show above this point a friable quartz penetrated in every direction with thin veinlets of oxide of iron, the remains of the original sulphuret. In many cases the gold carried by the sulphuret is now concentrated along these "iron stains," and on breaking the quartz and rubbing off the stains and panning them, the gold may be panned out, proving that it is now free gold. In the upper portions of these seams all of the gold is now free and is easily taken up by quicksilver. The old time miners, lacking the means for treating the undecomposed sulphuret, ceased their operations when it appeared in any consiberable amount. They mined thus only the upper portions of the seams, from which the gold could be obtained with comparative ease.

Where the decomposition has been going on for ages, as is the case in the Southern Gold Fields, and when the original sulphuret was rich and plentiful, it often happens that the residual oxide of iron forms veins of several inches in thickness and carries much gold. In the Rudisill Mine, near

Charlotte, N. C., there was a vein of this oxide of iron, along with other ores, about four inches thick that went down to a depth of 300 feet, and carried in places nearly $500 worth of gold per ton. At the Boilston Mine, in Henderson County, N. C., I have also observed these veins of iron oxide, one of them carrying $112 per ton. Such veins readily yield their gold to quicksilver, and constitute the best grade of ore in many localities.

One can now appreciate why these old miners made so many pits, trenches and shallow shafts; they were searching for ore that was easy to crush and easy to amalgamate. When they came upon the underlying undecomposed ore, harder and impregnated with sulphuret, they moved on to another place and repeated their operations. But after all, they left an incalculable amount of free milling ore, as the seams of which I speak are continuous for at least 15 miles, and probably extend for 30 miles. Even should this not be the case, assuming that the greater part of the free milling ore had been removed, an assumption by no means to be allowed, we now possess means for the economical treatment of the undecomposed sulphuret, which for ease, rapidity and thoroughness, leave but little to be desired. I refer to the Chlorination of Gold Ores, a full description of which will be found sn Appendix A. The sulphurets, the great Bug-a-boo of Southern gold miners, no longer vex us; they can be and they are treated for their gold contents with the most gratifying success. Apart from the sulphurets, however, and leaving them to be treated when they appear, it is my deliberate opinion that between Hillabee Bridge and the Birdsong Pits there is enough free milling gold ore to maintain a dozen stamp mills of 200 tons per day capacity at work profitably for twenty-five years. I have been over nearly all of the district twice and do not hesitate to say what seems to me to be the truth. The statement may and doubtless will be received by some with the customary smile of incredulity, the almost invariable accompaniment of assertions regarding the profitable treatment of Southern gold ores. The same smile did duty when the first assertions as to the Southern iron ores were made, when the Florida Phosphates were discovered and when coke making was begun in Alabama, and is still in good working order. It is as old as human nature and will outlive the last man.

In my examination of the Goldville Belt, extending from Hillabee Creek in a general north east direction to the Birdsong Pits, a distance of about 14 miles, I was particularly fortunate in having as my companion and guide Col. B. L. Dean, of Alexander City. He has been a resident of this part of Tallapoosa County for 36 years and has devoted more intelligent attention to the mineral wealth of the county than any one I know of. He is especially well acquainted with the region east of the Columbus and Western Railway and north of the Tallapoosa River. At my request he wrote a brief account of the Goldville Belt and I reproduce it here in his own words:

"The first work in this part of Tallapoosa County was done between 1840 and 1850 by Edward Birdsong, who has been dead for thirty odd years. He owned and mined part of S. W. ¼ and N. W. ¼ of Section 4, T. 24, R. 23. His widow, a resident of Columbus, Ga., was living in 1889. She could give more information about the mining interest in those days than any one I know. She said to me once that she was the cause of her husband's stopping work; the country was full of miners and she could not afford to raise her children where the Sabbath was a day of hunting and gambling. Her husband's work was carried on with negroes. In illustration of the gold fever she said that her negro cook, after attending to all of her duties at the house, would take her pan and wash out 75 cents worth of gold in a day, crushing the ore in a little hand mortar.

"Towards the south west we come next to the Jones Pit, in Sec. 5, T. 24, R. 23. On this property a great deal of work has been done with wooden stamps and the Arastra. There was also at one time a steam engine at the mine. Reports as to the yield of gold vary. The veins are from ten to twenty feet in width. (I have heard old miners say that in places the Jones Pits were very rich, W. B. P.)

"Next towards the south west we come to the Germany Pits, in the N. W. and S. W., Sec. 8, same township and range. It is said that Mr. Germany made money here. In this Section is located the town of Goldville, one of the oldest places in the county.

"Next in order are the Houston Pits, where much work has been done, but I know very little about them.

"The Log Pits are next, where also much work has been done.

"Next are the Ealy Pits in the S. W. ¼ of Sec. 26, T. 24, R. 22. A great deal of work was done here by Mr. A. Ealy and the Hon. Daniel Crawford, Ex-State Treasurer. Col. Crawford had great faith in this part of the county and was always on hand when any work was going on. I asked him once how he worked the Ealy Pits. He said that he made the machinery himself; four iron-shod wooden stamps run by water power at Jarvis' Mill. He hauled the ore two miles, crushed it with the wooden stamps and then "rocked" it in a rocker. I inquired what was the best run he had ever made in one day, and my recollection is that he said it was $73 or $75. After the death of Mr. Ealy, work was suspended, probably in 1845 or 1846, and has not been resumed since. I met a man once, named Collins, living in the northern part of the county, who had worked at the Ealy Pits and he told me that Ealy and Crawford got out some ore that ran $41 to the bushel. (Taking the bushel at 100 pounds, this ore was worth $820 per ton; pretty good stuff for those days. W. B. P.)

"Of the Stone and the Croft Pits, which come next, I know but little. A good deal of work was done from first to last, but nothing of record.

"The Mahan Pits, which come next, seem to be in the slate and a little off the main line of the quartz. Heavy sulphurets begin to show at the Mahan Pits, but the ore carries also free gold, as I have panned it out. Some of the ore was sent north several years ago by a Mr. Linds, and it assayed $22 per ton.

"Lastly, we come to the Ulrich Pits on the east bank of

Hillabee Creek. A great deal of work has been done here also, and much money spent to no purpose in shafts and drifts. The quartz is walled in slate dipping in some places nearly vertically, but as a general thing not above 45 degs. Dr. Ulrich sunk several costly shafts, hunting for copper, but as they were put down on the west side of the veins while they dip towards the east, the deeper he went the the farther he was from the ore. He finally discovered gold instead of copper, and erected a mill furnished with wooden stamps, taking the water for his power from Hillabee Creek. He worked in this way until the war, making his gold into bars and buying cattle with it, so I am informed by old citizens. Ulrich's operations were conducted without the least regard to economical mining, and with no thought for the future. The showing of ore at these pits and at the Jones Pits is greater than at any intermediate locality, and at these two places water is much more abundant and accessible than anywhere along the belt. Col. A. H. Moore had some of the Ulrich ore assayed in North Carolina, and told me that it ran $21 per ton

"On the west side of Hillabee Creek these seams continue in a south west direction, crossing the road from Alexander City to Hillabee Bridge on the the Duncan Place. This belt seems to be bounded on the east by a large slate dyke from 200 to 400 yards distant from the quartz seams. It crosses the Columbus and Western Railway in Coleman's Cut. This ends what I have to say about the Goldville Belt.

"About two and a half miles west of the Log Pits we find a great mass of ore in the Hog Mountain. There are millions of tons of quartz in the Hog Mountain, all of it carrying gold. I saw assays of ore taken from 16 different places and they showed the ore to be worth from $4 to $16 per ton. (Other assays of Hog. Mt. ore will be found under the appropriate heading, W. B. P.)

"From Hog Mt. we come south, in the same section to where William Conant worked in 1844 and 1845. It is said that he made money, using the crudest appliances and hauling the ore two miles with oxen.

"In Section 5 we find gold in the slates and heavy sulphurets in the shoals of Enittachopka Creek, the sands all along the creek for miles will pan gold.

"In all these places the quartz seams appear to go in parallel bands six or seven in a group and from thirty to forty feet apart. The same is true of Hog Mt."

This concludes Col. Dean's interesting and valuable letter. If there were others in the country who took the same intelligent means of informing themselves as to what has been done and what still remains to be done to develop legitimate gold mining the task of the prospector would be easier. He has faith in the future of Tallapoosa county as a gold producer and whether his hopes are fulfilled during his lifetime or not he may, perhaps, from another sphere be able to look down upon a score of mills, pounding away and proving the reality of what he labored so long to establish, the profit in quartz mining along the Goldville and Hog Mt. Belts.

Following is a list of the assays made on small samples taken along the Goldville Belt from Hillabee Bridge to the Jones Pits. It is not claimed for these assays that they represent in every particular the value of the ores, still they will show their general character. To sample these seams correctly would cost a good deal of money and the Survey has no means at its disposal for such an undertaking. The owners of the property should take the matter in hand, employ a competent engineer and furnish him with the means for opening the old pits or sinking new ones, so that average samples could be secured.

Assays along the Goldville Belt from the Duncan place, on the Hillabee Bridge road about 3 miles from Alexander City to the Jones Pits. Fourteen assays were made along this line, viz: one from Duncan's, five from the Ulrich Pits, two from the Ealy Pits, five from the Jones Pits, and one from what is known as the Chisolm Place, in Sec. 9, T. 23, R. 22. The value of the ore varies from $2 to $55.90 per ton.

No. 1282. Duncan Place, sugary quartz 2½ ft. width, sample from seam in road,

Gold......2–10 ozs. per ton.
Silver.....trace.
Value per ton, $4.13.

No. 1283. Ulrich Pits, old dump, reddish sugary quartz:

Gold......1–10 oz. per ton.
Silver.....trace.
Value per ton, $2.06.

No. 1284. Ulrich Pits, old dump, reddish sugary quartz.

Gold......4–10 oz. per ton.
Silver.....1–10 oz. per ton.
Value per ton, $8.36.

No. 1285. Ulrich Pits, old dump, reddish sugary quartz:

Gold......1–10 oz. per ton.
Silver.....trace.
Value per ton, $2.06.

No. 1286. Ulrich Pits, old dump, reddish sugary quartz:

Gold......1–10 oz. per ton.
Silver.....trace.
Value per ton, $2.06.

No. 1287. Ulrich Pits, old dump, reddish sugary quartz:

Gold......4–10 oz. per ton.
Silver.....2–10 oz. per ton.
Value per ton, $8.46.

No. 1288. Ealy Pits, yellowish sugary quartz:

Gold......1–10 oz. per ton.
Silver.....trace.
Value per ton, $2.06.

No. 1289. Ealy Pits, yellowish sugary quartz:

Gold......1–10 oz. per ton.
Silver.....trace.
Value per ton, $2.06.

No. 1290. Jones Pits, yellowish crystalline quartz, old dump:

Gold......1–10 oz. per ton.
Silver.....trace.
Value per ton, $2.06.

No. 1291. Jones Pits, old dump, reddish crystalline quartz:

Gold..
Silver.
traces.

No. 1292. Jones Pits, old dump, white crystalline and bluish quartz, with pyrite, and Arsenopyrite i. e. pyrite containing arsenic:

Gold......2 7–10 oz. per ton.
Silver.....1–10 oz. per ton.
Value per ton, $55.90.

No. 1293. Jones Pits, old dump, white crystalline quartz:

Gold......1–10 oz. per ton.
Silver.....trace.
Value per ton, $2.06.

No. 1294. Jones Pits, old dump, white crystalline and bluish quartz with pyrite and arsenopyrite.

Gold......9–10 oz. per ton.
Silver.....3–10 oz. per ton.
Value per ton, $18.90.

No. 1299. Chisolm Place, out crop of whitish sandy quartz, 6 ft. wide.

Gold......1–10 oz. per ton.
Silver.....trace.
Value per ton, $2.06.

HOG MOUNTAIN.

Copy of a letter received from Col. Jas. P. Dawson, Turner Building, St. Louis, September 18th, 1891:

ST. LOUIS, MO., Jan. 22d, 1889.

Elias S. Pepper, Esq.,
3rd National Bank, City :

Dear Sir—The sample of ore from..........marked.........., submitted to us for examination, contains

Gold......2.65 ozs. per ton.
Silver.....0.10 " "

Respectfully,

St. Louis Sampling and Testing Works,
WILLIAM B. POTTER, Mgr.
"S."

According to this assay the ore is worth $54.87 per ton. The letter was marked in pencil "Jones Vein."

In regard to the foregoing analyses I can only reiterate what has been already more than hinted at, that if the owners of gold properties desire assays which shall correctly represent the character and value of the ore, they should employ a competent and reliable mining engineer to make a detailed report. Samples taken at random may be correctly assayed and yet reveal but an indication.

Four miles almost due west from Goldville, two miles east of Hillabee Creek, and the same distance south from the Tallapoosa, Clay, line in Secs. 10 and 15, T. 24, R. 22, in Tallapoosa County, is the famous Hog Mountain. It derives its name from its peculiar shape when viewed from a distance. It attains an elevation of about 1,000 feet above tide and about five hundred feet above the surrounding country. It is composed in great part of quartz seams separated by bands of clay slate, highly metamorphosed in many places. A ledge of coarse granite appears among the slates of the hanging wall, i. e., the south wall, for the seems here are orientated contrary to the general run of the quartz in this part of the county. They bear almost due east and west, and, with the slates, appear to have been twisted around, the normal course being towards the north east. On the west side of the mountain there are enormous outcrops of quartz seams and massive boulders of quartz. One of the seams, known as the Blue Seam, shows 35 feet in width where it is uncovered. This seam was worked to a limited extent several years ago, and some good ore was taken out.* It bears east and west and dips to the south 30 degrees.

There is now a ten stamp mill, California pattern, with engine and boiler on the property, but no work has been done for several years. From the appearance of the more recent openings I think that perhaps 500 tons of ore were mined and milled, but I have as yet been unable to ascertain with what success. The ore is a sandy, friable quartz near the surface, but soon begins to harden, and at a depth of 15 or 20 feet is quite hard. At a depth of 20 feet in the Blue Seam sulphurets begin to come in and carry gold, as will appear from the assay.

The Tallapoosa Mining Company, of St. Louis, is now preparing to begin the work at the Hog Mt. on an extensive scale, so it is said. With a modern mill crushing from 200 to 300 tons per day, there is no reason why the Hog Mt. should not enter the list of profitable mines. There are millions of tons of workable ore in this hill. The main draw-back to any considerable operations here is the scarcity of water; there is no sufficient supply nearer than Hillabee Creek, 1½–2 miles. For this reason, and on account of the character of the ore, any company wishing to work on a large scarle would have to expend a great deal of money. The difficulties to be met and overcome, however, are no greater than have been successfully encountered elsewhere.

Through the kindness of Col. Jas. P. Dawson, Turner Building, St. Lonis, I can present some additional information concerning the ore from Hog Mt.

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*About one mile from the Hog Mt. towards Cowpens Tourmaline is abundant.

"Alexander City, Ala., May, 1889, pannings made on Hog Mt. by Wm. H. Cornell:

Veins.	No. of pans.	Showed gold.
1x2	11	7
2x3	9	6
3x4	20	13
4x5	10	8
5x6	12	7
6x7	8	4
7x8	5	5
8x9	6	4
9x10	4	2
	85	56

These pannings were all taken from the surface, and as near in diagonal as possible. The show was from three to thirty particles to the pan. From 3x5 the best."

Another letter from Col. Dawson enclosing two from Mr. Jewett, Assayer in charge, United States Assay Office, St. Louis, was received at the same time. From the assertions of Mr. Jewett in regard to some ore which Col. Dawson informs me was from Hog Mt., I find that it was worth $8.26 in gold and 36 cents in silver per ton.

Copy of a letter from the St. Louis Sampling and Testing Works:

"January 11th, 1889.

T. Wright, Esq., 3d and Olive Sts., City:

Dear Sir—We herewith enclose certificate of assay. The concentrates weighed 1.870 grams, 28.85 grains. It obtained from two ounces avoirdupois this would be a concentration of over 30 to 1. Unless the assay of the original is known, it would be impossible to say what loss attended the process.

Very respectfully,
St. Louis Sampling and Testing Works,
Wm. B. Potter, M'g'r."
S.

This letter is marked, in pencil, "Hog Mt." The certificate referred to was as follows, as per copy:

"St. Louis, Mo., Jan. 12th, 1889.

T. Wright, Esq.,
3d and Olive Sts., City:

Dear Sir—The sample of Pulp from............marked "Concentrates," submitted to us for examination contains

Gold..................4.37 ozs. per ton.
Silver................2.92 " " "

Respectfully,
St. Louis Sampling and Testing Works,
Wm. B. Potter, M'g'r. J."

Taking the total value of these concentrates at $93.24 per ton and the degree of concentration as 30 to 1, the value of the untreated ore would be $3.10 per ton.

Copy of a certificate of assay of what Col. Dawson wrote was "a number of pieces picked up at random on the mountain and assayed together."

"St. Louis, Mo., April 22d, 1889.

T. Wright, Esq.,
3d and Olive streets, City:

Dear Sir—The sample of ore from.........., marked............, submitted to us for examination, contains

Gold....................0.3 ozs. per ton.
Silver..................0.1 " " "

Respectfully,
St. Louis Sampling and Testing Works.
William B. Potter, Manager."

Taking these figures, the value of the ore per ton was $6.20.

Copy of another letter received from Col. Dawson:

"St. Louis, Mo., Oct. 2d, 1889.

T. Wright, Esq.,
3d and Olive streets, City:

Dear Sir—We have treated the barrel of ore you sent us as follows: The ore was crushed in a three stamp gold battery, with inside and outside amalgamated plates, using a 40 mesh screen, and the tailings were run over an Evans concentrating table with the following results:

Net weight of ore	502 lbs.
Containing gold	1.90 ozs. per ton.
" silver	0.1 " " "

The amount remaining in the mortar after the run was 219 lbs., assaying 1.90 ozs. gold per ton, thus giving 283 lbs. as the net weight of ore treated. The tailings from the plates contained, Gold........0.50 ozs. per ton, showing a saving of 73.7 per cent of the Gold.

The tailings, after passing over the Evans Table, gave the following results:

Headings	11 lbs., containing
Gold	1.60 ozs. per ton.
Silver	0.10 " " "
Middlings	48 lbs., containing
Gold	0.35 ozs. per ton.

The Headings contain 3 per cent of the Gold in the original ore, but it will be noticed that their grade is a little lower than the original ore.

The above results would indicate that your ore is fairly free milling. With a larger amount of ore, sufficient to make several runs under varying conditions, it is possible that somewhat better results might be obtained.

Respectfully,
St. Louis Sampling and Testing Works,
William P. Potter, Manager.
J."

According to this assay the ore was worth as follows:

Gold	$39.27
Silver	.10
	$39.37 per ton.

The following letter, also from Col. Dawson, is very important, showing as it does that at one time much more information concerning the Hog Mt. ores was available than is now the case.

"St. Louis, Sept. 8, 1891.

James P. Dawson, Esq.,
President Tallapoosa Mining Co.,
City:

Dear Sir—Replying to your inquiry concerning assay work done by my direction on Hog Mountain ore, I have searched all through my papers for the records but could not find them, and I do not know what I did with them. I had very many assays made, perhaps sixty or seventy, of the ore taken from different parts of that property, and of course can not remember them. I do remember that they ran as low as $2 and as high as $31, and I believe that they averaged $7.50, and I believe that they represented perhaps the true character of the property more closely than any other investigation ever made. I regret very much that I do not have the records, since I would be glad to give them to you.

Yours truly,

A. F. Hoffer.

The assays I speak of were made in '86 and '87."

I made four assays of ore taken at random from some old dumps on the Hog Mt. They ran from $6.20 to $58.67 per ton, the average being $24.53. They are as follows:

No. 1,295. Hog Mt., old dump, yellowish sugary quartz.
Gold......2 8-10 ozs. per ton. } Value per ton, $58.67.
Silver ....8-10 " " " }

No. 1,296. Hog Mt., old dump, whitish sugary quartz.
Gold......3-10 oz. per ton. } Value per ton, $6.20.
Silver.....trace per ton. }

No. 1,297. Hog Mt., old dump, yellowish sugary quartz.
Gold......1 1-10. } Value per ton, $22.73.
Silver.....trace. }

No. 1,298. Hog Mt., blue seam, bluish crystalline quartz, with a little pyrite.
Gold......5-10 ozs. per ton. } Value per ton, $10.53.
Silver.....2-10 " " " }

RESUME ON THE GOLDVILLE AND HOG MT. BELT.

1. No work of any consequence has been done for thirty years.
2. No reliable records are to hand relating to the work done prior to 1860.
3. Except at the Ulrich, Jones and Hog Mt. mines no good exposures of the veins are to be seen now. The old workings are fallen in and access to the seams is not to be had except at some expense, and the Survey has no means at its disposal for this purpose.
4. The assays of the samples taken show that the ores vary in value from $2 per ton to $58.67.
5. A large amount of work has been done by the old miners, and by reliable tradition some of it was very profitable.
6. The Ulrich and Jones Pits are well supplied with running water sufficient for extensive operations. The Hog Mt. is from one and a half to two miles from Hillabee Creek, the nearest available water supply.
7. An abundance of good timber of all kinds is within easy reach of all the Pits and of Hog Mt.
8. Profitable gold mining could be carried on in this part of the county.

THE SILVER HILL BELT.

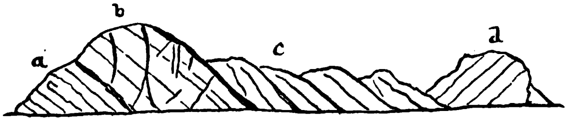
Silver Hill is in Secs. 16 and 17, T. 20, R. 22, Tallapoosa County, and is about 13 miles S. W. of Dadeville. Mining was carried on here probably as far back as 1835, but there are no records of what was done or of anything in connection with the work. There are abundant evidences that a great deal was done from first to last, for the old works are quite extensive, more so than at any locality in the County. A description of Silver Hill is contained in the Report of Prof. Tuomey, previously referred to as having been published in 1858. As he or Mr. Lieber, or both, visited the place before the shafts, drifts, &c., had fallen in as badly as they have now and as the description is well worth reproducing it is here given in full, taken from pages 47 to 50 of that Report.

Prof. Tuomey says:

"The talcose slates of Silver Hill are seen outcropping near Ufola, and the gold mine occupies the crest and flank of the hill which extends to the stream on which the mill is situated.

"The auriferous slates are enclosed between beds of hornblende. The following section will show the position of the mine:

Fig. 1.



Section of Silver Hill (after Tuomey.)

a. Hornblende slate.
b. Auriferous talcose slate, with veins of quartz.
c. Dark colored talcose slates.
d. Hornblende slates.

"This section is best seen at the base of the hill near the mill. Both *a.* and *b.* are quite hard, when placed beyond the influence of atmospheric agencies.

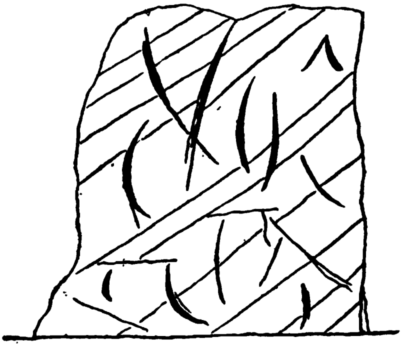
"About ten years ago this mine was in its most prosperous condition. About 150 feet of the principal vein was found out-cropping on the crest of the hill. It was 2 feet thick, but about 12 feet below the surface it became thinner and richer, at a depth of 15 feet it became poorer. It again thickened to 4 or 5 feet, and continued to improve in productiveness until it was abandoned.

"The vein, which was quartz, was worked to a depth of 80 feet in the centre, where it was richest. The ore was there worth $4.85 per bushel (about $96 per ton W. B. P.) The course of the vein was a little North of East. The usual mode of letting out the mine in small parcels was adopted here, and with the same results as elsewhere—the total ruin of the works. The vein is situated in Section 16, Township 20, Range 22. (The range is 21, W. B. P.)

"It has been recently re-opened with some prospect of success. An adit has been driven a little above the natural drainage of the Creek, with a view of striking the vein below the old works. Whilst this heavy work is going on, the proprietors are working some ore from the top of the hill. The ore is hauled by oxen about 250 yards to the mill, where I found 6 stamps, and a badly constructed Burke Rocker, in operation. The ore thus treated yielded only 12½ cents per bushel. (Say $2.50 per ton, W. B. P.)

"The principal vein was not exposed at the time of my visit, but some of the auriferous portions of the country, which were worked, presented the appearance shown in the cut, Fig. 2:

Fig. 2.



Quartz veins, Silver Hill, (after Tuomey.)

"The dark lines represent broken quartzose veins containing gold. On the branch, into which the drainage and surface water flows, signs of old works occur in the gravel deposited in its bed. Mr. Lieber, who examined this place more recently, reports as follows:

'The Silver Hill Mines, which were formerly abandoned on account of difficulties among the members of the company, are now worked by a Georgia company, with a prospect of success.

'The country is a talcose slate, one of the beds of which is of that peculiar black kind resembling black lead. Another talcose bed, in which quartz appears in irregular masses, is the one which is worked, the slate being also auriferous. This bed strikes North 70° East, and dips 15° to 35°. A quartz vein, leading from this, and striking North, is about 12 feet thick, including the selvages and the workable slate. The main body is 8 feet thick. Deeper down, the quartz will consolidate, in all probability, into a regular vein. Garnets and peroxide of iron occur, but all mixed confusedly with the slate. The black and grey slates are not auriferous, whilst the red, and portions of the white slates, are.

'The present company have driven two good adits, one of which is 400 feet in length, which, by draining a large amount of untouched ore, will enable them to win the contents of the mine for a long time, without any additional expense of consequence for drainage. The gold is said to be worth 95 cents per dwt.'

"On the opposite side of the branch, an immense series of quartz beds comes to the surface, which beds are more or less auriferous, and have even been worked, but with great difficulty, owing to the distance from water. They occupy the crest of a hill of considerable elevation, towards Blue Creek, forming an interesting feature of the landscape. (This ridge is known locally as The Devil's Back-bone, and extends for several miles in a North Easterly direction, W. B. P.)

"On the tributaries of the Creek, a great amount of gravel has been washed, in years past, for gold, and with much success, but these works have been abandoned years since."

Thus far Prof. Tuomey.

I can only confirm what is here stated as to Silver Hill, the work has been carried on in a haphazard way by first one set of miners and then by another. I could not get into the lower works but from what appears on the surface there is sufficient evidence of the wasteful and unscientific methods which were pursued. That there is good ore still at Silver Hill the following assays will show. The samples were taken at random from some old dumps:

No. 1276. Bluish crystalline quarts, carrying pyrite.
Gold......4 9-10 ozs. per ton.
Silver.....3 7-10 ozs. per ton.
Value per ton $104.98.
No. 1277. Yellowish suary quartz.
Gold .... 4-10 ozs. per ton.
Silver.....3-10 ozs per ton.
Value per ton $8.56.
No. 1278. Light yellow sugary quartz, gave traces of gold and silver.

No. 1276 represents the ore which is found in the bottom of an 80 ft. shaft, so I was informed by Mr. Isham Worsham, who worked at Silver Hill many years ago. Of course it can not be said that all the ore is of this quality, I am even disposed to think that but little of it is so good. Mr. Worsham described the vein as being about five feet in width and as carrying a good deal of sulphuret. The shaft was entirely filled with water at the time of my visit in August, 1891. I have some interesting letters concerning Silver Hill from Major C. H. Parmalee, Ass't. Treas. of the White Breast Fuel Co., 18 Broadway, N. Y. As they contain some valuable information regarding the value of the ore, I reproduce them here, omitting such parts as are of a purely personal nature.

Copy.

White Breast Fuel Co.,
18 Broadway, N. Y.,
Sep't 1st, 1891.

Mr. W. B. Phillips, Univ. Ala.

Dear Sir: Your very kind favor of the 27th Aug. received, also the report of the Thies Process of treating low grade gold ores, for which I thank you very much.

"Before the War," Prof. Emmons, State Geologist of

N. C., made an examination for me of the Silver Hill property. I will hunt it up and send it to you. Mr. R. C. Hills, the Geologist of our Coal Companies, also made a partial examination of Silver Hill and Gregory Hill. I think I have his letter and the results of some assays he made, which I will also send you. (Neither of these reports has come to hand, W. B. P., Feb. 15th, 1892.) Many years ago I had some assays made of Silver Hill ores but can only say that the lowest was $15.00 per ton and highest $500. Some Cincinnati parties a few years ago had assays made of Silver Hill sulphuret ores, and told me that the average was $30.00. I worked from the North end of Gregory Hill (two miles N. E. of Silver Hill, W. B. P.) ten years ago about 1200 tons of the ore, without any selection. It averaged $1.75 per ton. My screens were very coarse, and we knew but little about the business. .... I think that Gregory Hill would average, without selection, $2.00 per ton and at a cost of 50 cents per ton: ample water can be obtained for 20 stamps, say 60 tons per day. I think it would be safe to call the Silver Hill refactory ores $25.00. I once got $14.00 free gold per ton from 8 tons of refuse Silver Hill ore. It was hauled from the surface yard at Silver Hill to the 5 stamp Battery I had near Gregory Hill. Same screens were used. The ore was partially decomposed by weather exposure, say for twenty years. ....

Yours, C. H. P."

In this letter Major Parmelee also says in regard to Hog Mt.: "A Mr. Phillips, a mining engineer, examined Hog Mt. for Burke of New Orleans. He said to me it was a very valuable property because of the cheapness with which it could be worked. His test of the ore ranged from $6.00 to $16.00 per ton."

Copy.

"New York Club,
5th Ave. and 35th St.,
Oct. 2nd, 1891.

Mr. W. B. Phillips, Univ. Ala.

.... You are probably not aware that there is a shaft sunk about 90 feet down square on to the sulphuret vein—at least 30 feet or more below any of the old works .... It was in this shaft that Prof. Emmons examined the vein. It has been sunk about 20 feet deeper since that time. The old workings will not interfere with this shaft in any way. There is also another shaft on the same vein about 150 feet west of this (what I call No. 1 shaft) that can be cleaned out. The ore from these shafts will assay from $15.00 to $50.00. The vein so far as stripped averaged from 18 to 24 inches. This is very, very hard and so are the walls. ....

I am very truly yours,

C. H. PARMELEE."

At Dent Hill, half a mile north-east of Silver Hill, some work has been done on a curious mixture of talcose schist and quartz, but I was unable to find more than $2.06 per ton of gold in the sample taken. At this point begins the Devil's Back-bone, previously spoken of, and continues for several miles in a northeasterly direction. It is a very bold out crop of a sandy, friable quartz, almost like a sandstone, varying in width from six to fifty feet, and carrying some gold. From Silver Hill to a point opposite the Gregory Hill in Sec. 33, T. 21, R. 22, I took 8 samples but found no more than $2.06 of gold per ton in any on them. All showed this amount of metal. Seven of the samples were taken between Dent Hill and Farrar's Mill along the outcrop, the other one from a point on the ridge directly opposite Gregory Hill, where the wagon road crosses the vein. This tremendous out-crop of quartz is one of the prominent features of the landscape, as already remarked by Prof. Tuomey; and is remarkably uniform for miles. I was along it for about five miles and observed that at no place did it appear to show any deviation from its typical character. It is in most places stained of a light yellowish color, and, on crushing and panning leaves traces of undecomposed pyrite and black iron sand. It has occurred to me that the presence of gold in the highly graphitic schists of Gregory Hill and Blue Hill may be due to leaching from this enormous mass of quartz, the strike and dip of the two being nearly the same. These schists are in places very rich in free gold but do not yet evince the presence of pyrite; the gold is coarse and free. A fuller description of Gregory Hill and Blue Hill will enable one to see the force of this suggestion. The entire locality is brim full of interest to the geologist and to the practical miner, to the first on account of the association of gold with schists heavily charged with graphite, and to the latter on account of the ease with which mining can be carried on here.

GREGORY HILL: BLUE HILL.

Location, Sec. 33, T. 21, R. 22, Tallapoosa County. The ore here is a mass of highly graphitic schist holding numerous small seams of quartz. It is readily mined and easily crushed or stamped. I took two samples of twenty-five pounds each, from the top of the hill, mixed them well and the sample then gave

Gold......3-10 oz. per ton	Value per ton, $6.30.
Silver.....1-10 oz. per ton	

A good deal of work has been done here at one time or another. Major Parmelee has a fifteen stamp mill at work and as the ore is readily treated the stamps weigh 450 pounds each. There is not sufficient water for more than twenty stamps within a mile of the mill. I do not know what the ore yields in the mill. It seems to me that Rolls would do better work on this class of ore than stamps. There is sufficient ore in sight to warrant much more extensive works and I belive that with good management a handsome profit could be secured.

The same ore shows also a Blue Hill in the same Section. A sample taken from the mass gave

Gold......4-10 oz. per ton	Value per ton, $8.46.
Silver.....2-10 oz. per ton	

I panned several pans from Gregory Hill and from Blue Hill and each one gave coarse gold. At Gregory Hill it is almost impossible to take a pan from any place on the top of the hill, where the ore has been mined, without getting free gold, the surface earth yields good panning and when one takes the ore itself extraordinary results are obtained. I have never seen better panning anwhere than from this locality. I do not think that the operations at present conducted there are based on sound principles of mining or of milling. From the methods used there must be a considerable loss which could be avoided by a better system.

I was much pleased with the ore at Gregory Hill; while it may not run over $6.00 per ton yet it can be mined and milled at a slight expense. The chief item will be the water. There may be enough for fifteen or twenty stamps during a favorable season, but during "a dry spell" the supply becomes scarce and uncertain. But little work has been done at Blue Hill yet the general character of the ore is the same as at Gregory Hill. The neighboring ravines have been prospected and some of them washed for gold during wet weather, and I was informed by Mr. Isham Worsham, an old miner of these parts, that he had often gotten good results from the gravel. Gravel washing, however, owing to the scarcity of water, is not to be considered either at Gregory Hill or at Blue Hill, unless indeed the waters of Blue Creek be called into use by means of powerful pumping machinery. This is a bold stream of water and could be tapped at a distance of about one mile. For twenty or thirty feet in depth the ore at Gregory Hill could be easily disintegrated by the hydraulic process, and if it should be proved by experience that stamps do not suit the ore I know of nothing better than the treatment referred to.

Other localities in Tallapoosa County have been the seat of old mining operations, or, rather of gold washing, as for instance the Long Branch about one mile south of Silver Hill, where a great deal of work has been done, with good results. The Owl Hollow, in the same vicinity, is also another famous place for gold gravel. The Long Branch is, next to Silver Hill, the most famous place in this part of the county, as tradition informs us that it yielded much gold forty and fifty years ago. I was unfortunately prevented from visiting it, nor did I see the Owl Hollow. I am informed by old miners that the cream of the gravel in both places has long since been removed.

At the Bonner–Terrell Mine, about ten miles north-east of Dadeville, some work has been done, but I could not visit it and hence have no assays of the ore and know nothing about it except that it is said some of the ore was very good.

Near Perry's old mill on the Tallapoosa River, not far from Dudleyville, according to Tuomey, is the Morgan Mine. He says (Report of 1858, p. 64): "This is situated on a branch very near the river. It is a deposit mine, composed of a thick bed of coarse gravel. Some veins in the neighboring rocks appear to be auriferous. The mine was just opened at the time of my visit and was attracting much attention."

The south-western corner of Tallapoosa County below the Long Branch, is the southern limit of the gold region of the State. It is said that a little placer mining has been carried on in the north-western part of Elmore where it adjoins Tallapoosa County, but I have been unable to find any reliable evidence that it was more than a mere prospecting.

Chambers County, also, belongs to the Lower Gold Belt, but so far as is known no gold mining has been attempted within its borders. Heavy quartz seams are found in the county as far south as LaFayette, but they have not been examined. It is very likely that the northern portion of the county is penetrated by some of the seams belonging to the Goldville Belt. Investigations on this point will be undertaken during the summer of 1892 and the results will appear in the next report. Two complete sections across the gold fields will also be incorporated in the Report on the Upper Gold Belt as it was thought best to defer this until the lines could be run to the Alabama–Georgia boundary.

It is likely that the outlook in the Upper Belt is better than in the Lower Belt, particularly in the vicinity of Arbacoochee, where placer mining has been carried on for fifty years, and Bell's Mills, Idaho, Extension Mine, Pinetucky (where a ten-stamp mill is now at work), and other localities in Cleburne, Randolph, Talladega and Clay Counties. The survey to be undertaken this summer (1892) will cover these localities.

APPENDIX A.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

N. Y. MEETING, Sept., 1890.

THE THIES PROCESS OF TREATING LOW-GRADE AURIFEROUS SULPHIDES AT THE HAILE GOLD MINE, LANCASTER COUNTY, SOUTH CAROLINA.

BY A. THIES, CONCORD, N. C., AND WM. B. PHILLIPS, UNIVERSITY OF ALABAMA, TUSKALOOSA, ALA.

1. *Introductory Remarks.*—The Haile Gold Mine is in Lancaster county, South Carolina, 3½ miles east of Kershaw station on the Charleston, Cincinnati and Chicago Railway. It was first opened about the year 1832, and since that time has passed through various fortunes. Many different operations have been practiced here for extracting gold: panning, grinding in Chilian mills or arrastras, stamping, the Designolle process, dry crushing, and finally the Thies process of barrel-chlorination, which has now been in successful use for 2½ years, and by which 36,000 tons of ore have been treated profitably.

The Thies process is in brief the treatment of dead-roasted auriferous concentrates (pyrite, sometimes also chalcopyrite, as at the Phœnix mine, Cabarrus Co., N. C.), with nascent chlorine, without artificial pressure or exhaust, in lead-lined iron cylinders; the throwing of the mass on a sand filter; and the quick filtration and precipitation of the gold chloride with fresh and active ferrous sulphate. The gold is precipitated as metallic gold of a reddish-brown color which, after being allowed to settle completely, is collected, washed, dryed and melted with soda and borax in graphite pots and cast into bars.

The efficiency and economy of the process are such that, in working on a large scale, crude ore of the assay-value of $4 per ton, carrying about one-third of its gold free and two-thirds in sulphurets, can be profitably treated. At the Haile mine 36,000 tons of such ore have been successfully treated, and it is now mined and treated at the rate of 80 tons per day of 24 hours.

It should be observed at the outset that the chlorination system here used is not patented. Any one is free to employ it; and therefore what is said of it in the present paper is without any bias of commercial interest. It is the second attempt to introduce into the southern gold-fields, on a large scale, the chlorination of roasted ore in place of amalgamation, and as an adjunct to amalgamation before roasting.

The uniform and most gratifying success attending the use of this process for several years at the Phœnix mine, Cabarrus Co., N. C., (see TRANS. xvii., 313) induced the owners of the Haile property to introduce it at these mines under the personal supervision of Mr. A. Thies. Mr. Thies' improvements on the old Mears chlorination process have been fully set forth in the paper above referred to. Without severing his connection with the Phœnix Co., he took charge of the Haile mine in January, 1888, where he operated 20 stamps from that time to January last, and since the latter date, has added 40 stamps, making a present total of 60 in operation.

By this process of chlorination there have been treated since 1880 at the Phœnix mine 5,000 tons of concentrates, and at the Haile, since May, 1888, the date of the beginning of the work here, 2353 tons.

This statement is sufficient evidence that the process is conducted upon a commercial scale, and has long since passed the experimental stage. There is now no more reason to doubt its success as applied to low-grade auriferous sulphides than to doubt the success of the Thomas process in the manufacture of steel. Nor is it too much to claim for it that it stands metallurgically towards the other and older processes for the extraction of gold as the Thomas process stands towards the other and older processes for the manufacture of steel. Both these processes were successfully applied about the same time. They are vital improvements upon the ideas of previous unsuccessful applications; and they deal with materials that hitherto had baffled all attempts at utilization, the one with high-phosphorus iron-ores, and the other with low-grade sulphuret gold-ores.

In order to realize the especial significance of the Theis process to the metallurgy of gold, it is only necessary to recall the history of southern gold mines for the past fifty years. It is a history of disappointed hopes. The capital invested in such mines has been, to say the least, extremely unproductive. Even during the last six or eight years, when any one who chose might have ascertained for himself the true method of treating these ores, the old state of affairs has continued, and the old story has repeated itself.

The elements combined in this successful solution of the problem are concentration, roasting and chlorination. They go hand in hand; each is incomplete without the others. But what distinguishes this process from all others is the method of applying the chlorine to the roasted ore, of which we shall speak later.

Since a complete account of the process requires some notice of the conditions under which it is employed at the Haile mine, this paper will briefly describe the geological occurrence of the ore; the operation of mining and transportation to the mills; and the milling and concentrating; after which an account will be given of the roasting and chlorination, including the delivery of the gold-solution to the precipitating-vats, and finally, the precipitation, collection and smelting of the gold.

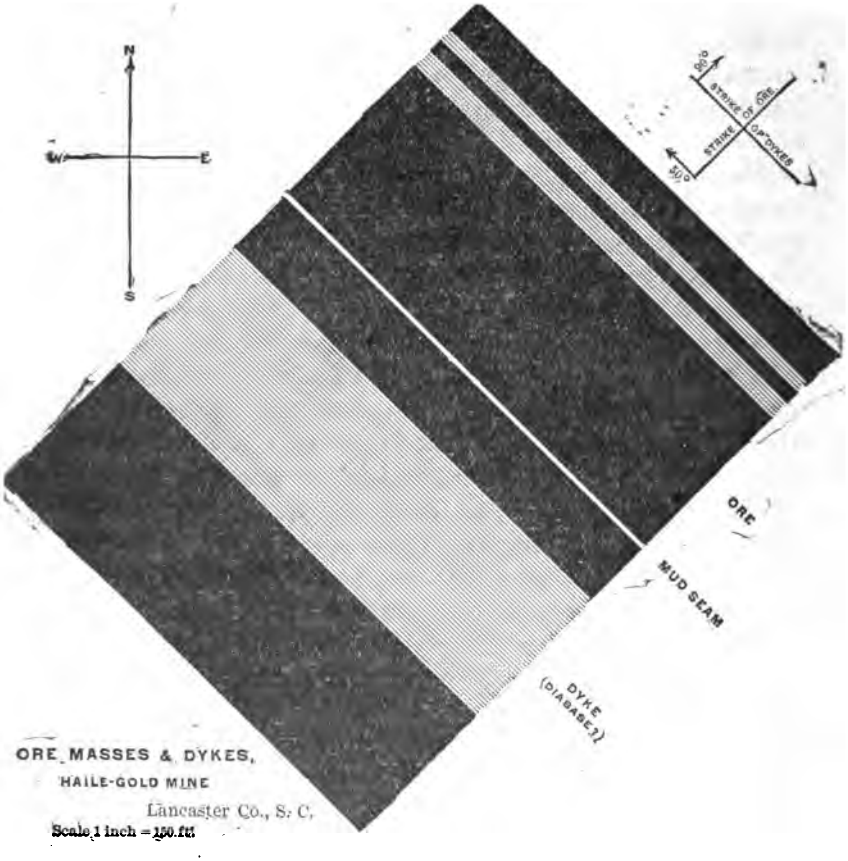
2. *Geological Occurrence of the Ore.*—For a more detailed description of the geological conditions, the paper of Messrs. Thies and Mezger, which is presented simultaneously with this, may be consulted, and reference may be conveniently made to the geological sketch-map by Mr. Mezger, which accompanies that paper. It is not intended here either to controvert or fully to adopt the conclusions there set forth, the simple reason being that the two papers have been

prepared independently, and there has been no subsequent consultation of all the writers concerned.

The ore at the Haile mines is a mixture of pyrite and stratified talcose slate. The strike of the strata varies from N. 52° E. to N. 73° E., and the dip (nortwesterly) from 45° to 75°. The foot-wall is soft talcose slate, colored yellowish, brownish and red by iron-salts, and showing cross-joints. The hanging-wall is (often if not always) greenstone. From the foot-wall towards the hanging wall there is a well-marked increase in the hardness of the ore; bands of siliceous matter appear, and veinlets and veins of almost pure pyrite, from the thickness of ¼ inch to 1½ foot. These streaks of pyrite cut across the slates in all directions and are also at times parallel to them. Now and then masses of considerable hardness are also found near the foot-wall, but whether they occur here or in the vicinity of the hanging-walls, they are evidently derived from the talcose slates. It is believed that whatever be the earthy material mixed with the slates in the ore-bearing mass, it has been derived from the slates themselves. Even the very siliceous material found near the hanging-wall and bearing no close resemblance to the slates either in color, hardness or stratification, was doubtless derived from them.

Several dikes, seemingly of diabase, cross the slates at irregular intervals. On the accompanying diagram they are shown as cutting the slates at right angles to their strike. This is not quite true; but the variations are slight. Between these dikes lie the immense deposits of talcose slates, impregnated with gold bearing pyrite and with more or less free gold. The free gold is generally fine. Wherever the slates are rich enough in free gold and in pyrite, they are mined. The richer streaks are of various widths, from 2 feet to 30 feet, and are of the same general character as the main body of the slates. In immediate proximity to the dikes, as well as to the hanging-walls, the slates are, as a rule (with some exceptions) richer than elsewhere.

As to the correlation between the dikes and the ore-masses, little will be said here. That the dikes do influence the richness of the ore favorably seems to be beyond question, but it is not so easy to say why. Nor can we speak positively as to the nature of the dikes themselves. They stand nearly vertical; they cut the strike of the slates nearly at right-angles; they exercise a favorable effect upon the richness of the ore; but whether they are strictly diabase or not, and whether they are of plutonic origin or not, will not be discussed here.



ORE MASSES & DYKES,
HAILE-GOLD MINE
Lancaster Co., S. C.
Scale 1 inch = 150 ft.

3. *The Mining and Transportation to the Mills.*—In such thick masses of ore, choice must be made between taking out all the ore (sustaining the walls with timbers) and taking such ore as can be extracted, using as little timber as possible, and leaving pillars. The first plan is not to be thought of here, on account of the varying value of the ore, the enormous amount of timber required and the expense connected with keeping it in sound condition. The other plan was therefore adopted and has worked satisfactorily. The levels are driven from 60 to 70 feet apart and connected at different points by winzes which serve during stoping as ore-shoots. Between these winzes main pillars are left, while the ore is stoped on each side of the pillars from hanging to foot, leaving sufficient solid ore against the hanging-wall to insure safety.

Of the mines partly opened and worked in earlier years, the Bequelin (formerly known as the Blauvelt) is now in active operation. The main shaft has reached a depth of 194 feet on the dip of the ore, of which 15 feet are used for a sump. The levels are driven east and west from the shaft at intervals of 60 feet, and the ore is trammed from chutes at the 180 foot level to the main station to be hoisted by double skips to the surface. From 80 to 100 tons are hoisted in 24 hours.

The system of mining would require for its full discussion a separate paper. It may be characterized here as the pillar-system (Pfeilerbau) generally employed when excessive timbering is to be avoided.

The drilling is done by double-hand, single hand and machine-drills. For this latter purpose there are 4 Ingersoll-Sargeant Drills of 3½-inch cylinder, now used entirely for development-work.

The plant at the Bequelin shaft consists of 2 boilers, of 90 and 35 horse-power respectively, which, under full headway, carry from 75 to 80 lbs. steam-pressure, consume about 6 cords of pine wood in 24 hours (at a cost of $1.40 per cord, delivered), and furnish steam to one 20x30 Ingersoll air-compressor, one 40 horse-power Dickson reversible link-motion hoisting engine, one 20 horse-power crusher-engine for a 20x10 Blake crusher, and one No. 9 Davidson mining pump, of 200 gallons per minute capacity. The ore is hoisted in skips which discharge automatically upon two grizzlies and thence to the crusher. One man can load 60 tons per ten hours on the skips, which hold 1500 lbs. each.

The grizzlies have each a square surface of 32 feet, and the bars are set 1½ inches apart for the "shaft-smalls," while the coarser ore goes directly to the 20x10 crusher. The grizzlies and crusher discharge into an ore-bin, holding 30 tons. From this bin the ore is hauled by a narrow-gauge locomotive ¾ mile to the mill; a trainload being 7 cars carrying 3 tons each. An engine-driver and two boys look after the loading of the ore from the bin on to the cars, the transportation to the mill and the discharging into the mill-bins. They also keep the track in repair.

4. *Milling and Concentrating.*—There are at present 40 stamps working; 20 more are up, but not quite ready to begin dropping. The average amount of ore crushed per stamp per 24 hours during the last 4 months is 2.01 tons. The stamps weigh 750 lbs. each, and drop 5¼ inches 84 times per minute. The screens are 36-mesh, of brass wire. Formerly 40-mesh slotted Russian sheet-screens were used, but these were discarded in favor of the wire-screens, the latter not only possessing greater durability, but giving a far more uniform pulp for concentration. The average life of the wire-screen has been 6 weeks, while slot-screens often had to be thrown out in 14 days. The average amount of water used per stamp is 3½ gallons per minute, and the average consumption of quicksilver per ton of ore is 0.35 ounces. The average wear and tear of shoes and dies per ton of ore stamped is 1.3 pound.

The area of inside-plates per battery of 5 stamps is 1.75 square feet, and of outside-plates 32 square feet, with a 2-inch inclination to the foot. There are 3 boilers of 50 horse-power each and one Harris-Corliss engine of 150 horse-power. The 40 stamps are run with a steam-pressure of 50 pounds.

The mill is of the back-to-back type, 30 stamps on east and 30 stamps on west side. Each double battery has its own cam-shaft, which is driven by belt from a pulley on the shaft common to all the stamps on the same side. The east battery-shaft and the west battery-shaft are driven by steel bevel-gearing from the main shaft.

The railway-cars are bottom-dumpers, and discharge their ore on the iron-plated comb, dividing the east-side bin from the west-side bin. These bins hold 150 tons each, and discharge their ore into Hendy self-feeders. The angle of inclination of the bin-bottom towards the self-feeders is 60°. The battery-tailings are conveyed to the concentrator through open launders 8x10 inches, with cross riffles, one inch high, every 8 to 10 inches. Total length of launders, 78 feet; inclination, $\frac{1}{2}$ inch per foot. The launders discharge into a box from which runs a series of small launders at right angles to the main launder, to each concentrator. There are 16 Embrey end shake concentrators, 8 to each 20 stamps. The distribution table for the battery-tailings is provided with an amalgamated copper plate for saving any free gold, amalgam or free quicksilver which may escape from the outside battery-plates. The belts are set with $2\frac{5}{8}$ inch inclination and travel 5 feet per minute. The number of strokes is 192 per minute. The yield in concentrates per ton of ore stamped averages 9 per cent., *i. e.*, for each 11 1-9 tons stamped, there is a yield of 1 ton of concentrates. The loss in sulphurets is about 10 per cent.

The fire-assay value of the ore delivered to the stamp is $4.50 per ton. The mint-returns of bullion give $3.90 per ton of ore treated, of which $1.45 is to be credited to the stamps, *i. e.*, to free gold, and $2.45 to sulphurets. Taking the value of the ore at $4.50, and the actual yield in bullion at $3.90, we have an indicated loss of 60 cents per ton, or $13\frac{1}{3}$ per cent. Taking the yield in free gold at $1.45 per ton from an ore worth $4 50 per ton (or approximately 32 per cent.), we have 68 per cent. to be sent into the concentrates. But the total yield in free gold and in gold from the sulphurets is $3.90 per ton, so that the ratio of the free gold saved to the total amount saved is approximately 38 per cent., and of the combined gold 62 per cent. An ore of this kind therefore carries about one-third of its gold free and about two thirds combined.

We have used the term combined gold to express the condition of the gold that is not free. Whether the gold that is not free is chemically or mechanically diffused in the sulphurets. or both, is not known. Much has been written upon this subject; but as yet we are not warranted in adhering positively to either view. One thing appears certain, viz.: that, no matter what may be the state of the gold in such material, it must be thoroughly roasted before it can be profitably extracted. From the 80 tons of ore stamped per 24 hours, there are obtained 7½ tons of concentrates, which gives as the yield of each concentrator, a little less than one-half ton. The concentrates are piled in a shed and thence conveyed by rail to the furnaces, a distance of 1200 feet. The average assay-value of the raw concentrates has been, for the last 12 months, $30 per ton. This corresponds closely to the estimated value. Assays vary from $25 to $35 per ton of 2000 pounds. The percentage of sulphur in the raw concentrates varies from 40 to 45 per cent. In roasting, this is brought down to from 0.25 to 0 40 per cent. and the value of the material per ton is increased by one-third, *i. e.*, a raw concentrate of $30, becomes a roasted material of $40 per ton.

5. *Roasting and Chlorinating.*—The roasting-plant consists of one pan revolving furnace (of the type described in the paper by one of the writers previously referred to, *Trans.* xvii., 313), two double-hearth reverberatories, each of 400 square feet roasting-surface, and one American Spence furnace.

The capacity of the pan-furnace for twenty-four hours is 2½ tons of roasted ore (equal to 3⅓ tons of raw concentrates) and that of each reverberatory furnace 2 tons of roasted ore (equal to 2⅔ tons of raw concentrates). The yield of roasted ore per day of twenty-four hours is 6½ tons from one pan and two reverberatories. The consumption of wood is one-half cord for each furnace per ton of roasted ore. Each furnace is attended by four men for twenty-four hours, who do all the work of charging, firing and rabbling, and also deliver the roasted ore on the cooling floor. They are paid $1.00 per day of twelve hours. The wood used is pine and costs $1.40 per cord delivered. Mr. Spilsbury, in a paper read before the Institute in 1883, (*Trans.* xii., 103) puts the roasting-capacity of the reverberatory furnace at 6 to 10 tons per day of twenty-four hours. This is not practicable when the product is to be so roasted as to be suitable for chlorination. No such feat has been accomplished in *that kind* of roasting by any furnace, modern or ancient, automatic or otherwise. It should be added that the roasting to which Mr. Spilsbury refers was followed by amalgamation.

In November, 1889, an American Spence furnace was built, but the expectations entertained concerning its operation were not realized, and the furnace, after many unsatisfactory attempts, has been idle since. The difficulties encountered were: 1st, the matting of the iron rakes whereby they were prevented from swinging on their axis; and 2d, the banking of the ore on both ends of the shelves.

The first difficulty, viz., the clogging of the rakes by the fine ore, was in part overcome by providing the rake with a sheet-iron hood. But although this gave some help, it did not altogether remove the trouble. The swinging of the rakes on their axis is a *sine qua non* of their efficiency, and just in the measure in which this is prevented, in the same measure is the roasting hindered. If the rakes cannot swing they cannot rabble the ore, and without this no thorough roasting is possible. This trouble is intimately connected with the second difficulty, viz., the banking of the ore at the ends of the shelves.

Under the present construction of the furnace the difference between the length of the roads which move the rakes is 6 inches, so that when the ore drops from a shelf to the one underneath, the rake on the lower shelf is 6 inches in advance of the rake on the upper. This distance is not sufficient to prevent the fine, red-hot ores from falling upon the lower rake as they are discharged from the upper shelf. These ores move very easily—they may almost be said to flow; and they begin to fall through the opening when the rake is 12 to 14 inches from it. In this way the ore falls in front and on top of the lower rake, and is pushed by it towards the end of the shelf. In its back-stroke, the rake, being clogged by the fine ore falling on it, cannot take with it all of the ore that it pushed forward. Some is left, and the pile grows larger and larger, until finally the entire end of the shelf is full of ore. The alternate pushing and pulling of the clogged rakes causes a banking of the ore at both ends of the shelves. After several weeks of continual trouble and worry it was finally decided to discontinue the attempt to utilize this furnace for chlorination-roasting.

The principle on which the Spence furnace works is correct in every detail, and it is undoubtedly the proper furnace for roasting coarse ores for smelting purposes where a complete elimination of the sulphur is not wanted. A chlorination-roast, however, must be a uniform dead-roast, and no furnace which will not deliver material in that condition can be used.

From the furnaces the ore goes to the cooling floor where it is allowed to cool; then it is dampened with water and elevated to the chlorination-floor.

The chlorination-plant consists of two chlorinators, eight filters, two storage-tanks for the filtered solutions, thirteen precipitating tanks, two settling-tanks for precipitates, a storage-tank for sulphuric acid, and a tank for preparing the ferrous sulphate (copperas).

As regards the chlorination, no better description of what is now done at the Haile can be written than is contained in a letter from Mr. Thies to Mr. C. N. Aaron, published in the Eighth Annual Report the State Mineralogist of California, 1888, pp. 844–846.

Mr. Thies says:

PHŒNIX MINES, OCTOBER 15, 1888.

C. N. AARON, ESQ., SAN FRANCISCO, CAL.

Dear Sir: In my former letter I promised to write an article on the "Hydrometallurgy" of gold, but seeing, through the pressure of business, that it will be impossible for me to do justice to the subject to get it ready for print by the 1st of November, I will here give you a brief description of the barrel-chlorination as in practice at the Phœnix mines, North Carolina, and the Haile gold-mine, South Carolina.

The success of barrel-chlorination I attribute to the generation of chlorine in the ore-pulp, to attrition and to quick filtering. The original Mears process was based upon the presence of chlorine, either generated outside and forced by a pump into a lead-lined cylinder through a hollow trunnion or generated by the use of chloride of lime and sulphuric acid in such quantities as would create a pressure of from 30 to 40 pounds per inch. To ascertain the pressure, a lead-lined gas-pipe in the form of a goose-neck (and called so), passed through the hollow trunnion, was securely fastened, provided with a stuffing-box and connected with a pressure-gauge. In using chloride of lime, the inner lead-lining of the cylinder was provided with a sulphuric acid chamber capable of holding 100 pounds of acid. While, indeed, the result in working well-roasted ores was satisfactory, the annoyance through leakage; the continual wearing out of goose-neck; the collapsing of the inner lead-lining by a too strong exhausting of the gas; by being too often deceived as to the presence of chlorine, when pressure but no chlorine was present, causing rehandling of the ore, made the process an expensive and unsatisfactory one.

In this annoying way I worked for nearly two years, testing meanwhile the effect of a highly saturated chlorine-water under attrition without pressure, and when, after repeated tests, I found my results equally as good without pressure as with the highest pressure (and better when I divided the requisite amount of chlorine and sulphuric acid, so as to have the nascent gas during the time of working), I remodelled the chlorinator by closing up the hollow trunnion and removing the goose-neck and acid-chamber and substituted a lead valve, connected with the inner lead-lining in such a way that the presence of free chlorine can be ascertained at any moment, and no charge subject to chlorination need be thrown on the filter without full knowledge of the work being complete.

The cast or sheet-iron cylinder (chlorinator) is 42 inches in diameter by 60 inches long. The heads are cast and securely bolted to end-flanges and provided with tight and loose pulleys. The bung for the introduction of the roasted ore and chemicals, 6 inches in diameter, is provided with a lead-lined cover, which, before rotation, must be closed hermetically.

The interior of the cylinder is lined with sheet-lead of 10 to 12 pounds per square foot. The capacity of the chlorinator is from 1 to 1¼ tons of roasted ore. Before introducing the ore, the chlorinator is charged with from 100 to 125 gallons of water, or, I might say, with enough water to make an easy-flowing pulp. This done, the roasted ore is introduced, half the requisite quantity of sulphuric acid is then poured in, and lastly, half the required chloride of lime. when the bung-hole is closed and the chlorinator is set in motion at the rate of fifteen revolutions per minute.

For Phœnix ores I used 40 pounds of chloride of lime and 50 pounds of commercial sulphuric acid per ton of roasted ore; but I charge 20 pounds of chloride of lime and 24 pounds of acid first, rotate for three or four hours, open the bung and charge the other half, having found better results in dividing tne chemicals. Rotate for two or three hours longer, and if, by the aid of the lead valve, free chlorine is found present the cover is removed from the bung-hole and the chlorinated ore is thrown on a shallow filter, 6 by 8 feet, provided with a 5-inch filter-bed, over which the pulp spreads to a thickness of about 4 inches.

The filter. before the ore-pulp is thrown on it, is first flooded with clear water from below, and when the water stands over the filter the discharge-hole is opened, so that the water acts as a cushion against the ore-pulp, prevents the packing of the filter-bed and admits of a free filtering.

When the chlorinator has been emptied on the filter the cork is removed and the solution allowed to pass into a stock-tank below. As soon as the first solution has passed through, so that the ore-surface is exposed, from 3 to 4 inches of water is added over the whole surface; and when this is filtered through and the ore-surface exposed again the whole space above the ore, about 11 inches in depth, is filled, which, by practice on Phœnix ore, has proved sufficient to remove all the chloride of gold; but should there be still a reaction with ferrous sulphate more water must be added.

The filters are lead-lined, 18 inches deep, and have a fall of 1 inch towards the outflow. The bottom is first covered with perforated glazed tiles or clays or mineraline, which is impervious to the action of acids and chlorine. On this rests the gravel filter-bed, which is topped off with ordinary clean river-sand. To prevent the filter from getting an uneven surface, longitudinal 1¼ inch wooden slats, 8 or 10 inches apart, keep it in place.

The filtering should be accomplished as quickly as possible, but, as this depends generally on the fineness of the ore treated, no rule can be established. As long as the solution shows the presence of chlorine when the last wash-water has passed through the filter, there is no danger of not having clean tailings. The solutions accumulating in stock-tank are let off into smaller tanks for precipitation with ferrous sulphate, which should always be regenerated, if not active, so as to destroy any ferric sulphate. Care should be taken by examining, after twenty-four hours. to ascertain if all the gold had been precipitated, as losses have occurred by a partial precipitation. The tanks for precipitation should not be too deep; a convenient size is 6 to 8 feet in diameter and 3 feet high, holding the solutions from about 3 tons of roasted ore. A sufficient number should be on hand to allow the precipitate at least three days to settle. After three days settling in shallow vats, the supernatant liquor can be drawn off and fresh solutions added for precipitation.

At the Phœnix, the liquor is passed over metallic iron, and the copper is recovered as cement. From the precipitating-tanks the precipitate is finally collected, washed as clean as possible to remove the iron-salts, dried and melted.

The amount of chloride of lime and acid used at the Phœnix I have stated as 40 and 50 pounds respectively, which is due to the presence of an appreciable amount of chalcopyrite. An excess of acid should always be used so as to convert all the lime into a sulphate to remain in the filter. The solution should be slightly acid. If neutral, soluble chloride of lime will cause a bulky precipitate with ferrous sulphate. At the Haile mine, where I have to deal with a pure "iron sulphuret," I use at present but 10 pounds of chloride of lime to 15 pounds of acid, and treat 4 tons of roasted ore in two chlorinators during ten hours, and I have not failed to extract 94 per cent of the assay-value.

The Haile mine ores, which have been so long the bugbear for economic treatment, and on which so many experiments have failed, are offering no obstacles to the barrel-chlorination, and are cheaper and easier to chlorinate than the Phœnix ores.

As the success of chlorination, by whatever process, depends on a thorough roast, assuming that we have clean concentrates, it is of the utmost importance that the roaster should have some guide to go by, and to this end, I let him test every charge before drawing by a bright-filed iron-rod. A small portion of the roasted ore is boiled in water and stirred with the bright iron. The least trace of sulphates will stain the iron,—a sign for the workmen that the roasting is not completed.

At the Phœnix, I use a revolving pan furnace of 12 feet diameter, with a short reverberatory attached. From two working doors the roaster can rabble the ore. When a charge is finished, the ore is discharged through the hollow axis on which the pan revolves into an outer circle below, and is then removed by scrapers attached to the bottom of the pan into a car, and delivered to the cooling-floor, from which it is elevated into the chlorination house. Such a pan furnace roasts 1 ton of raw ore in twelve hours, with a consumption of three-eighths of a cord of wood and 90 cents for labor. The power necessary to drive the pan is a small item, and will not exceed 25 cents per ton of raw ore.

At the Haile mine, a double reverberatory furnace furnished 2 tons of ore every twenty-four hours, with an average consumption of 1 cord of wood at $1.25 per cord and four laborers. The cost per ton of roasted ore amounts to $2.62½.

The cost of chlorination by the barrel process depends chiefly on the number of tons chlorinated per day. Two men can easily chlorinate 4 tons in ten hours, elevate the ore and clean out the filters, of which I have four to each chlorinator; and having arranged on this basis the work at the Haile mine, the cost for chlorinating 4 tons daily is as follows :

40 pounds of chloride of lime at 3 cents	$1.20
60 pounds of sulphuric acid at 2 cents	1.20
2 barrels at 90 cents	1.80
1 chlorinator man	2.00
Motive power	.50
Total	$6.70

or $1.67½ per ton.

Add to this 12½ cents for sulphuric acid for making sulphate of iron, and 20 cents for repairs and wear, which is more than liberal, and we have the sum of $2 per ton for chlorination, or $4.62½ for roasting and chlorinating 1 ton of roasted ore, representing 1½ tons of raw iron pyrites. Inside of seven hours from the time the ore is in the chlorinator, the solutions are ready for precipitation and the tailings are clean.

The wear on the inner lead-lining of the chlorinators is imperceptible,—a chlorinator in use at the Phœnix for over five years does not show any wear on the lead.

That the barrel chlorination has advantage over the Plattner process can not be gainsaid, and its successful working here and at the Bunker Hill, Amador county, California, where it surpassed the Plattner in results, will undoubtedly lead to its adoption in regions where the auriferous sulphurets are an important factor in the production of gold.

Hoping that these notes will aid you in your work, and ready to give any desired information,

I remain very truly yours,

A. Thies.

This description is as true of the Haile to-day as it was two years ago. The amount of chemicals varies between 10 and 15 pounds for chloride of lime and 15 and 20 pounds for sulphuric acid. The assay-value of the tailings from the chlorinator, which are removed from the filter-bed and thrown over the dump, is, on an average, $2 per ton.

6. *Precipitation, Collection and Smelting of the Gold.* The ferrous sulphate employed as a precipitant should be used fresh, and to this end it is made up fresh for each day's run. It is easily prepared from one day to another.

As already observed, care must be taken to see that the precipitation is complete by testing the solutions about twenty-four hours after precipitation. Generally, the total absence of chlorine and a sweetish odor are fair indications of a complete precipitation after a thorough stirring with ferrous sulphate.

At the end of a month's work, or whenever it is deemed necessary, the completely-settled precipitate is taken up from the precipitating-vats into small lead-lined tanks 2 feet by 4 feet in size and 2 feet deep, in which it is allowed to settle again for twenty-four hours. The supernatant liquor is then syphoned out, and the precipitate is washed with boiling water until freed from most of the iron salts. It is then collected on filters, dried and melted in Dixon crucibles with borax and soda, and shipped to the United States Assay Office at Charlotte, N. C. Its fineness varies between 975 and 985.

The successful treatment of 2,353 tons of concentrates from the Haile mine by this process is all the more gratifying because of the failure of all other processes here to work at a profit.

It is commended to those who have to deal with large quantities of low-grade sulphurets in the belief that it will solve their difficulties, and enable them to work such ores profitably. For simplicity, cheapness and adaptability to such ores, it cannot be too highly praised.

(At this time, February, 1892, there are 60 stamps running at the Haile, and the process, under the skillful management of Mr. Thies, continues to justify the expectations based upon it. I can heartily commend it to all who have low grade sulphuret ores to treat. W. B. P.)

APPENDIX B.

METAMORPHIC ROCKS OF COOSA, TUOMEY'S REPORT OF 1858, pp. 43 TO 47.

It was stated in a previous report that the metamorphic rocks terminated at Wetumpka. Beds of gneiss, passing into mica slate, occur here in great force. The edges of the strata rise up boldly from the bed of the river, but are covered by drift from the banks. The rock is coarse, splits with ease, but the bedding planes are uneven. The strike is north-east and south-west, and the dip 75° north-west.

Turning east above the Penitentiary, and passing over the undulating surface of the drift, to where the road crosses Coon Creek, below the ford, a ledge of rock is seen, which resembles that of Wetumpka, excepting that it is rendered porphyritic by flattened crystals of pink feldspar, that lie between the laminae of mica. Although coarse, this rock is strong, and the contrast between the color of the feldspar and the black mica gives it an agreeable appearance. The crystals of feldspar are compressed, and interlaced by the mica; the rock may be called a porphyritic gneiss. At this locality another bed of white gneiss occurs. It resembles very much the rock at Tallassee, both in color and compactness, and it would make an excellent building material. Although no quarry is opened, the rock may be examined at the ford. With the exception of the denuded beds of streams, the rest of the country is composed of drift, covered with one unbroken pine barren, to the Tallapoosa.

Above the falls of Tallassee, the river is wide, and divided by little islands, into numerous channels which unite near the barrier of gneiss, which crosses the stream in a direction nearly East and West. The pent up water has forced a passage through this natural dam, and foaming amongst the vast masses of rock, sends its spray to the winds. The gneiss is fine grained, and compact, but not thick bedded. Immediately at the falls the strata are worn into pot-holes, some of which are eight feet in diameter. The water, often pouring into these finds an outlet between the strata, which in time are completely under-mined, and in this way most of the huge masses lying around have been broken off from their original beds. The entire fall, at the Factory at the foot of the falls, is sixty feet. In summer, when the banks are fringed with green and beautiful shrubs, this place presents a scene of picturesque wildness, that will repay the labor of a visit. On the right, the valley is quite narrow, and a well located road, exposes on its side the beds of drift which rise to a height of 200 feet above the river.

It would be difficult to conceive of a more favorable locality for manufactories, on a large scale, than this. The whole of the river is precipitated, through a narrow gorge, over a fall of 60 feet, and in a distance of 8 miles the river falls 800 feet.

The Factory recently erected here, at a cost of $30,000, presents a fine example of the adaptation of the rock of the falls to building purposes.

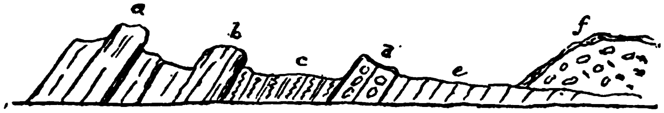
On the side of a little stream, called Slone's Mill Creek, which empties into the river below the falls, the gneiss becomes slaty, and excellent flagging stones could be quarried. Although such materials are found elsewhere in the State, I know of no locality so favorable as this.

The first falls on the river occur two miles South of Tallassee, at the site of the old Indian village of Tuckabatcha. (Pickett's History of Alabama, Vol. I, page 124, gives Took-au-batche-tal-lau-hasse as the name of a town among the Upper Creeks in 1778, W. B. P.)

The river, after following the metamorphic rocks till they are covered to a great depth by the drift, turns directly West to join the Coosa, four or five miles below Wetumpka.

Section from Tallassee, on the bed of the river, to Tuckabatcha:

Fig. 3.



Section from Tallassee to Tuckabatcha. (after Tuomey)

a. Beds of gneiss, forming the Tallassee Falls, strike East and West dip towards the North 40°.

b. Flagging stones finely exposed on Slone's Mill Creek: course of the joints which intersect the quarry, North 20° West.

c. Mica slates.

d. Thick strata of slates with bosses of feldspathic and coarse crystalline granite protruded through them. Rounded masses of quartz are found embedded in the slates, and when the latter are worn away, they rest on the surface like large boulders.

e. Micaceous and talcose slates, containing lentiform nodules of graphite between the slates, which abound in garnets. The graphite, when divested of the slates, is very pure, but unfortunately the pieces in which it may be procured are not very large. The strata extend across the bed of the river, and as the banks are covered with alluvium can only be seen at low water. The locality requires a more thorough examination than I could give it at the time of my visit.

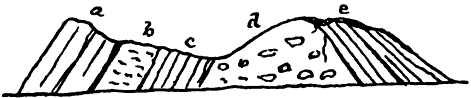
f. Beds of drift.

North of the falls the rocks become talcose, and on a little stream, called Coon Creek, beds of hornblende and soapstone occur. In a hollow, near the creek, a bed of soapstone of great thickness is found. This seems to have been well known to the Indians, who resorted to the spot for the purpose of manufacturing culinary utensils. Excavations, of considerable extent, were made on the best portions of the rock, and the sides of the excavations are curiously pitted where the vessels have been cut out. It appears to have been their practice, to inscribe on the rock the circumference of the pot or bowl to be cut out, and then excavate around it until a sufficient depth was attained, after which the mass was split off and finished. Occasionally, when failure in splitting off the mass ensued, pieces remain attached to the rock. Everywhere the impression of the bottom of the vessel is left on the face of the quarry.

The rock is calcareous, effervescing with acid. Crystals of pyrites are abundant, but no other minerals, excepting actinolite and talc, are found here.

These Indian excavations have deceived many inexperienced persons, who supposed that they were made for the precious metals. The soapstone of this locality extends across the county to Chambers, and at intervals throughout this extent it is perforated by such excavations. This is the locality which excited so much interest at the Tallapoosa Silver Mine.

Figure 4.



Section on Coon Creek (after Tuomey.)

a. Gneissoid rock extending to the mouth of the Creek.
b. Sienitic gneiss, with flat crystals of hornblende.
c. Hornblende slate.
d. Soapstone, 100 feet thick, out-cropping on Penn's land.
e. Hornblende.

The strike on the rocks in this section is South, South-west, and North, North-east, dip of the bed at *e.* South, South-east, and of the gneiss at *a.* North, North-west.

From this point to Silver Hill hornblende slates are everywhere displayed, with the exception of the occasional occurrence of beds of gneiss, as may be seen on the Sougahatchee, where the rock passes into talcose slates. The course of the rocks here is North-east and South west, dip 40 degrees

North-west. The country is composed of rounded hills, covered with a warm, brown soil, common to hornblende rocks. Such soils suffer from excessive drouth, but for the production of grain they are amongst the very best.

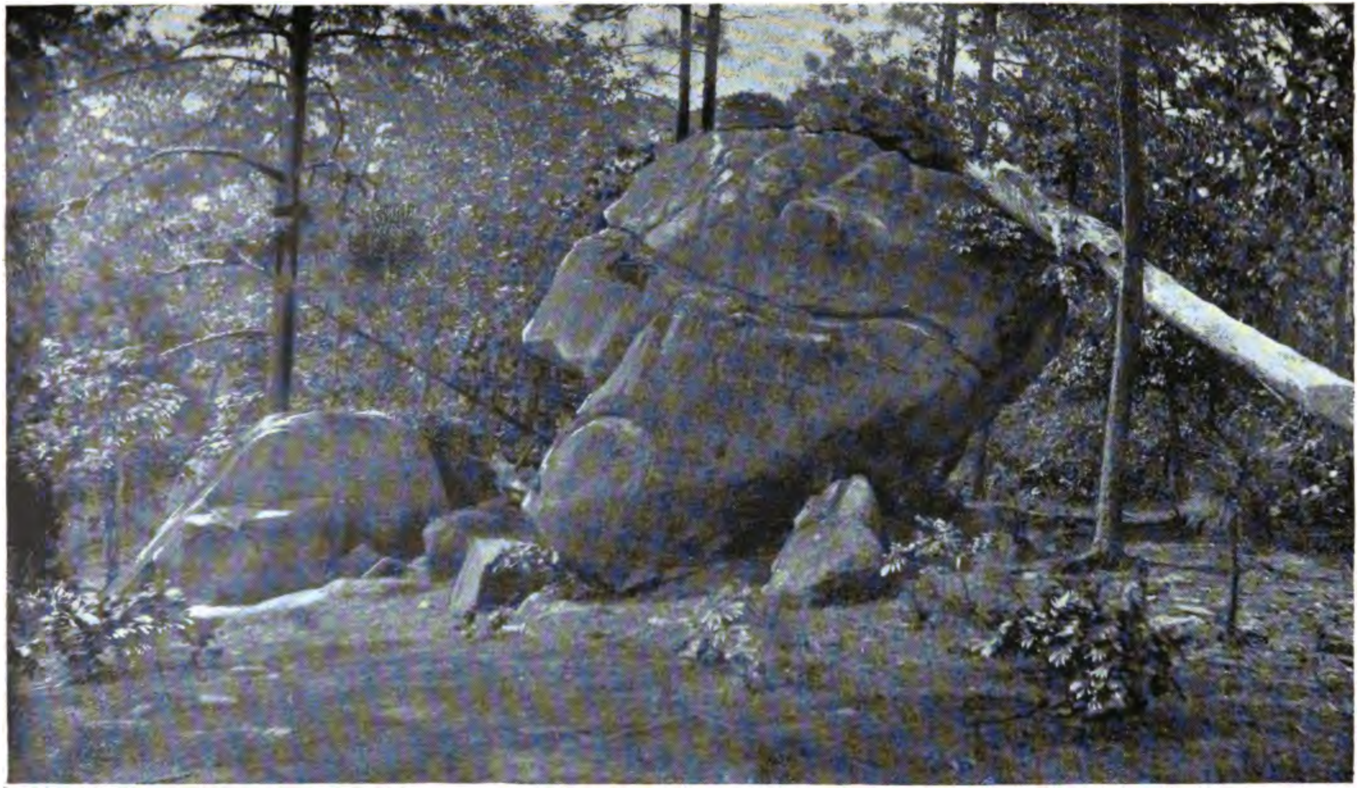
GRANITE OF COOSA AND TALLAPOOSA (pages 77 and 78).

Around Rockford large weathered masses of a whitish gneissoid granite are found on the surface. Sometimes immense fragments are undermined and broken off by their own weight. (Three photographs of such masses are shown herewith, taken by myself during the summer of 1891. W. B. P.)

On the way to Bradford I saw another trial shaft, sunk, I believe, in search of silver. There was really no reason to expect any profitable result from exploration here. The shaft was sunk on a bed of coarse slate abounding in rough garnets. It is true, that mica slate containing garnets is a promising metalliferous rock; still we must have some positive evidence of the existence of some valuable metal in the rock before we commence expensive operations. The rock in question contained the merest trace of copper, not more than one might expect to find in any of the rocks of this region.

At Bradford, gneiss is finely exposed at the Factory, where it is cut up into prisms by joints running North 20 degrees East, across the stream; the fall here is thirty-five feet. A mile further up it becomes more granitic, and rises above the surface, in the manner of the masses at Rockford. On the surface it is weathered, sometimes inclined to disintegration, and where it is feldspathic produces a fine porcelain clay; this clay I found excited interest at some of the mines. At Mr. S. S. Graham's the rock is hard, very white, and clings to the hammer. It would be difficult to find a more beautiful building material. It belongs to the great gnessoid granitic belt that extends along the northern portion of the Southern States.

It is seen again at Blake's Ferry on the Tallapoosa. In hand specimens, and even the largest masses exposed, it presents no appearance of stratification; it is, notwithstand-



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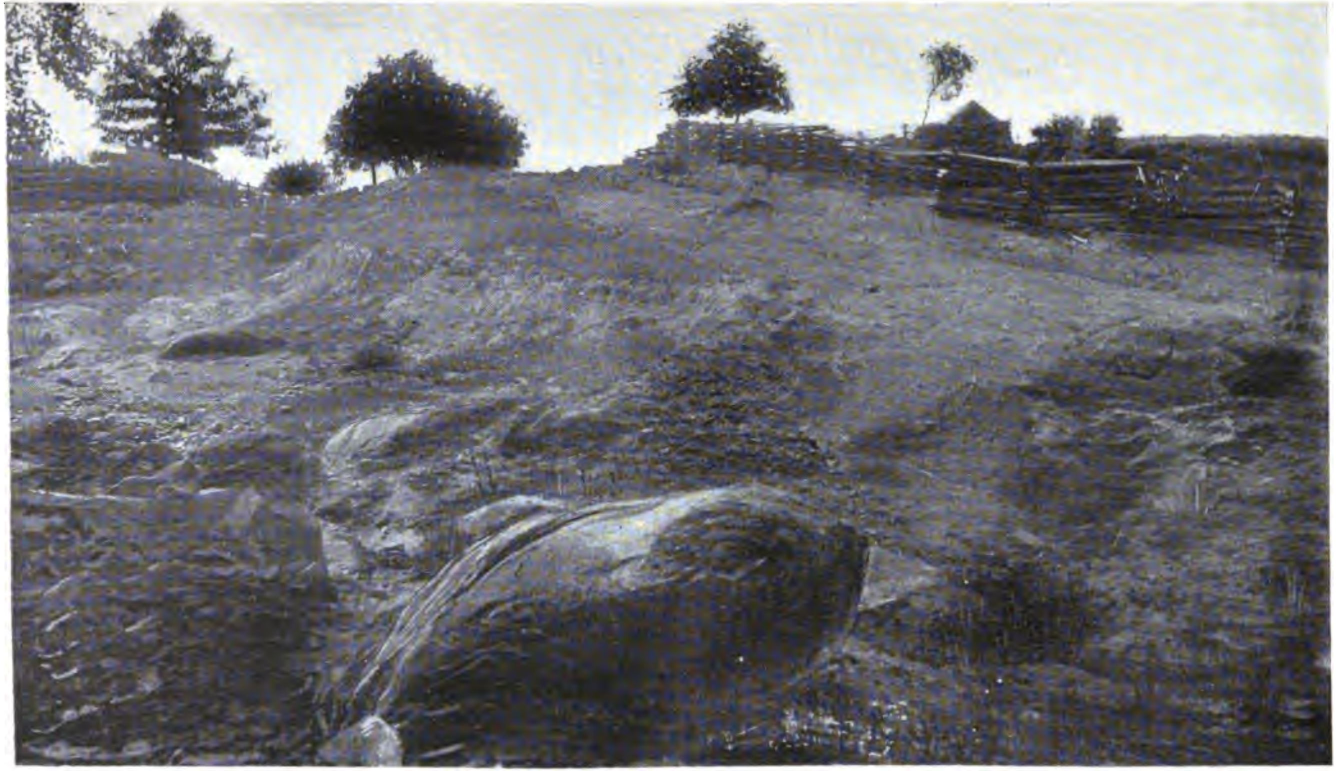

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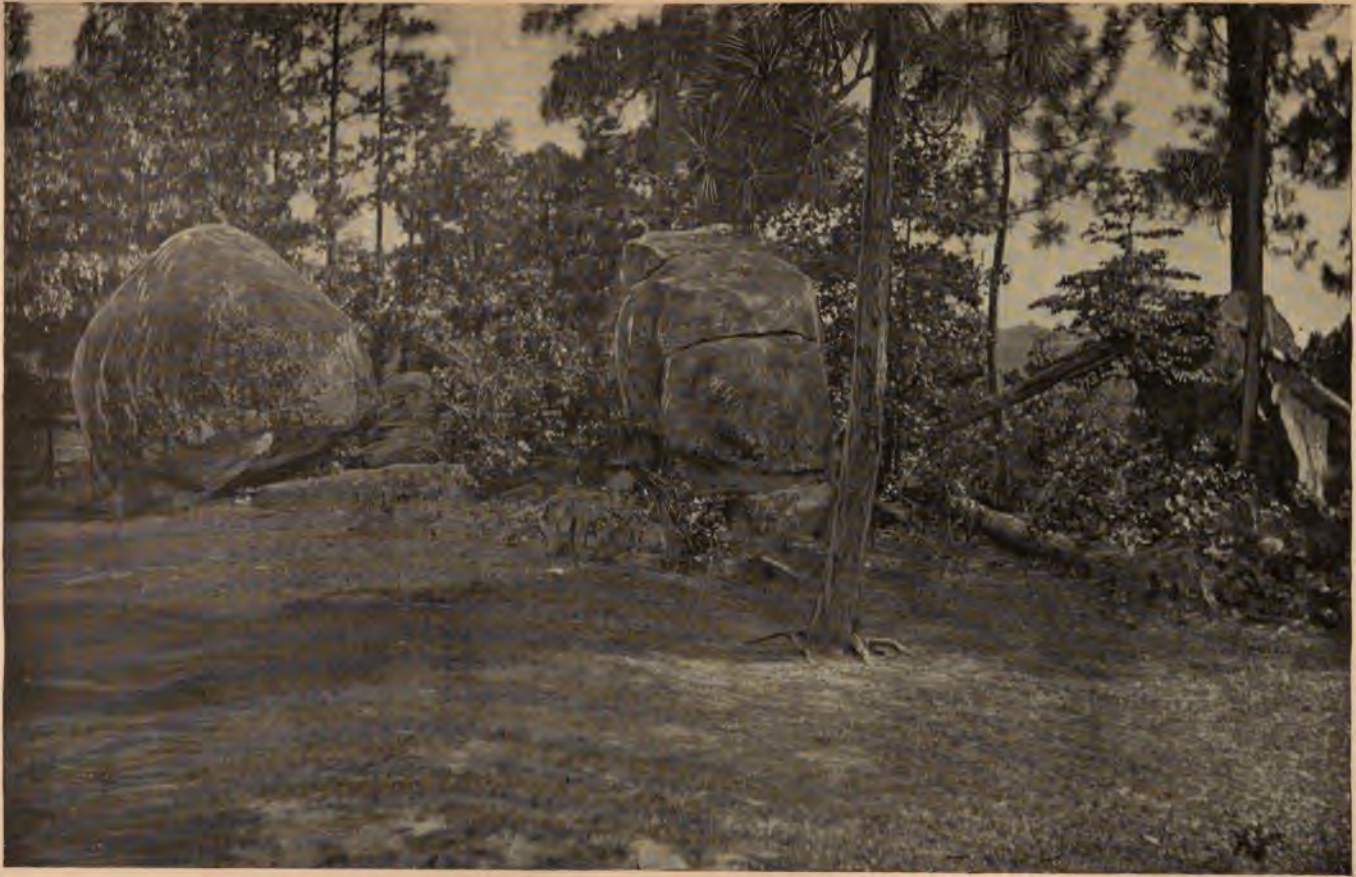

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ing, interstratified with mica slates, has the same strike and dip, and must therefore be called gneissoid granite. The plank road, to a distance below Powelton, passes over the disintegrated edges of the gneissoid rocks, with only here and there a bed of hornblende. The grey soils of this region owe their excellence, for the production of cotton, to the underlying rock. The physical features of the country are also favorable; the surface is undulating, but not broken. On Chenahatchee a very peculiar gneissoid granite occurs, in which the mica is not regularly distributed through the rocks, but occurs in small patches, contrasting curiously with the white feldspar of the rock.

APPENDIX C.

[From Tuomey's Report of 1858, pages 73 to 77.]

STEWART'S GOLD MINE.

This old mine is in Sec. 4, T. 23, R. 17, Coosa County. The auriferous portion of the ridge is about 200 feet wide, and was at first worked in open cut; but the ridge is perforated by shafts, at intervals, for a distance of one-half mile. This mine was worked for some time with stamps, but has long since been abandoned. Masses of bronze colored pyrite are scattered among the refuse; they seem to be portions of a vein cut in the mine, and are more or less auriferous.

The Weoguffka Mountains are composed of talcose slates, which are finely presented at the point where the Weoguffka Creek crosses the Rockford road. About thirty-three miles above Wetumpka the ridges assume a greater elevation, and from their tops the broken character of the country can be seen. The country is covered with a magnificent forest of long leaf pine, which, when seen from above, presents a peculiarly rich and luxuriant appearance. The talcose slates are suceeeded by mica slates, which continue till they pass into the gnessoid rocks, near Rockford. On the way to Rockford I examined a curious locality, where immense masses of ferruginous matter occurred on the surface, and excited hopes that they would turn out to be copper gossan; and a shaft was sunk under the supposition that the gossan would be cut at the proper depth below the surface. But, unfortunately, these masses were formed in the same manner as the ferruginous tuxa (tufa?) of Randolph, and did not extend below the surface at all.

Near Rockford, on the land of C. W. Chancellor, there occurs an auriferous deposit of gravel and clay, a portion of which was once worked. Of the gold mines of Coosa Mr. Lieber speaks as follows:

"The old mine near Mr. Griffin's in Coosa occurs in Sec. 4, T. 23, R. 27 E. The works having fallen in nothing is now to be seen. It produced well at one time, and an engine was mounted on the spot, but want of skill, together with mismanagement, prevented success. The auriferous gravel deposits of Alabama present some very peculiar and interesting features. It would be difficult to circumscribe them with regard to their geographical occurrence, since gold is found, in greater or less quantity, in almost all the gravels and sands of the creeks and branches of the metamorphic region, extending even as far South as the Tallapoosa, twenty miles east of Wetumpka, where traces of gold exist. The deposits of the Weoguffka and Hatchet Creeks, in Coosa County, demand, perhaps, the greatest attention. On Messrs. Thomas and Samuel Lambert's place, in Coosa, some of these beds occur, and a fine opportunity is afforded for observing them. The 'packed gravel,' as it is locally termed, immediately underlies the soil and débris of the surrounding rock, and is usually about a foot or eighteen inches in depth. The beds contain a large amount of clay, so that their unctuous touch serves to distinguish them with the hand even under water, from the dry débris which overlies them. The quartz of the gravel is throughout of orange color, of a kind I have not seen in any other auriferous region. It belongs to that compact granular quartz, commonly called 'sugar quartz,' and is probably identical with that which, in Australia, has received improperly the name of 'cairngorm." It is worthy of remark, that I have but in one solitary instance found this peculiar quartz in place, though making its discovery a matter of careful attention. This was at Mr. Richmond Noel's, in Randolph County, Secs. 4, 5, 8 and 9, T. 22, R. 10 E. The bed is here two feet thick, and holds a position between a bed of gneissoid eurite, containing, however, a little white mica, and a body of gneissoid granite, which is the same as that at Hunter's. It crops out in the bed of a branch, whose gravel has been found to be auriferous. The quartz, when newly broken, resembles lumps of good brown sugar. The color is pale lemon within, and orange without. Occasionally pieces are seen which pass from a blood red to a deep claret color, and on the fresh break exhibit correspondingly redder tints than the other.

"To return to the gravel deposits of the Weoguffka: the largest quartz boulder observed contained about four cubic feet. All these, from the smallest to the largest, are much rolled, although the larger ones are not so much rounded and still roughly indicate the original forms of the broken pieces. In these gravel beds we rarely meet with pieces of the slates, gneiss, &c., which are found so abundantly in the dry and not gold bearing beds covering them, and where no powerful action has tended to round the constituent pieces of rock. I am inclined to believe that Zereuner errs in enumerating gneiss as one of the rocks found in the auriferous gravel of Alabama. The specimen had probably fallen in from the upper beds. Occasionally the deposits widen to 150 or even 300 feet, but always depend upon the width of the little valleys. Owing to these depositions the surface of the ground in the valleys is singularly level, and has afforded space for the accumulation of very good soil. Branches are found in some, but not all, of these valleys. The gravel pans from four to twenty particles of saveable gold of a fine color, and there is scarcely a doubt, but that, if suitable locations were selected and proper contrivances chosen for extracting the gold, very profitable operations would be the result, especially when we bear in mind the greasy nature of the gravels, in consequence of which only the very coarsest particles of the metal are saved in panning. The utmost attention should be paid to this fact also in the treatment on a large scale. The Hatchet Creek deposits include what is termed the Miller Gold Mine in Sec. 1, T. 24, R. 20 E., and another close to it in Sec. 11, of the same Township and Range. The former, or old Miller Mine, usually paid about $1.75 per hand, the latter only $1.00. The former was last worked in 1847, by T. Phillips, of Nixburg, with six or eight hands, and averaged, during the summer, from 75c. to $1.00 per hand per diem. The ground worked is extensive, and we find upon it both gravel beds and decomposed talcose and micaceous slates with interspersed masses of itacolumitic quartz. Both were worked, and the operations were all exposed to day, so that now all is in confusion and decay. As many as fifty hands were engaged here, at the same time, in the summer of 1843. The operations were commenced in 1840, but frequent interruptions took place, and indeed these mines were only resorted to when no other employment presented itself. The gold was of a very superior quality and better than that at the old mine, which was formerly worked near the Weoguffka. This spot, if properly managed, might yet be made very productive, and indeed the old gravels might again be worked over to advantage; as a proof of which it may be proper to state that, in the summer of 1854, a man engaged in this operation quite alone, and made over $1.00 a day, by the roughest treatment. Ill health prevented his continuing. Messrs. McElrath Bros., of Cherokee County, now own two-thirds of this mine. The whole valley seems to be auriferous, for a Mr. Ford, an old resident of the neighborhood, now of Texas, sank many pits about, and found only one in which he was unable to obtain gold. It has been already stated that it is impossible to point out all the occurrences of deposit gold in Alabama, and it is almost as difficult to ascertain all the localities at which it might be profitably worked, especially as it may require a long time before a really efficient treatment can replace the present barbarous processes. Future discoveries, too, will probably develop far more than it is possible to show at present."

The country around Weoguffka and ~~Hatchet~~ Creeks is

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doubtless the most broken portion of the State occupied by the metamorphic rocks, yet in the valleys the soil is good and productive.

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GEOLOGICAL SURVEY
OF
ALABAMA.

EUGENE ALLEN SMITH, PH. D., STATE GEOLOGIST.

BULLETIN No. 4.

REPORT ON THE

GEOLOGY OF NORTH-EASTERN ALABAMA,

AND ADJACENT PORTIONS OF

GEORGIA AND TENNESSEE.

BY

C. WILLARD HAYES,
Assistant Geologist, U. S. Geological Survey,
1892.

MONTGOMERY, ALA.:
SMITH, ALLRED & CO., STATE PRINTERS AND BINDERS.
1892.

To His Excellency,

THOS. G. JONES,

Governor of Alabama:

DEAR SIR:—I have the honor to submit herewith Bulletin No. 4 of the Geological Survey, a Report on the Geology of Northeastern Alabama and adjacent portions of Georgia and Tennessee, by C. Willard Hayes of the U. S. Geological Survey.

The circumstances which have led to the preparation of this report are briefly these: It has been the avowed policy of the present Director of the United States Geological Survey so to prosecute the work of that Survey in the several states as to make it as useful as possible to the State Surveys. In pursuance of this policy it was agreed some years ago between Mr. G. K. Gilbert in charge of the Appalachian Division of the U. S. Survey, and myself, that a measured section should be made by the United States Survey across the line of outcrop of the geological formations of northeastern Alabama and the adjoining part of Georgia. After full conference the line of this section was so chosen as to embrace the lower end of Lookout Mountain near Gadsden; the section was to be about twenty miles wide, and the thickness of the various geological formations crossed by this survey was to be carefully measured, correlations of these formations with those of other states were to be made, and the geological structure of the region accurately determined. This done, the work of the State survey in the same field could be confined, in great part at least, to the investigation of the natural resources, and a voluminous report is now partly in manuscript descriptive of the deposits of iron ore, clays, limestones, and other useful minerals of this region.

As mentioned by Mr. Hayes, the original plan of this U. S. Survey work has been somewhat modified so that the present bulletin includes a description of a much larger area than was at first intended. This is, however, to the advantage of our survey since we get the report free of all cost for field and office work, which represents by far the greater part of the expense.

Yours very respectfully,

EUGENE A. SMITH.

UNIVERSITY OF ALABAMA, July 1, 1892.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C., June 12, 1892.

DR. EUGENE A. SMITH,
State Geologist,

DEAR SIR:—I have the honor to submit herewith the manuscript of a report on the Geology of North-eastern Alabama and adjacent portions of Tennessee and Georgia. Although the greater part was written in 1890, various unavoidable delays have prevented its completion till the present time.

I have indeavored in writing the report to keep it as free as possible from technical terms and without sacrificing scientific accuracy, to present the facts in such a manner as to make them intelligible to the largest possible number of readers in the region under consideration. Many details which would be of interest to the geologist have been purposely omitted and only those which were considered essential are given. It is expected that the atlas sheets covering this region will shortly be published by the U. S. Geological Survey and supply the details to those specially interested, which are omitted from this report.

Very respectfully,

C. WILLARD HAYES,
Asst. Geologist U. S. Geological Survey.

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I. INTRODUCTION.

Field Work.—The information embodied in the following report was obtained during the summers of 1887, 1888, 1889 and 1890, in connection with the mapping of atlas sheets under the Appalachian Division of Geology, U. S. Geological Survey. In 1887, the writer accompanied I. C. Russell through the southwestern portion of the area described, assisting him in the completion of surveys made the previous year. Three months the following summer were spent by the writer in mapping the northeastern half of the area, and some of its eastern portions were revisited in the fall of 1889 in connection with work then being done in southeastern Tennessee. In all about five months previous to the summer of 1890 were spent by the writer in actual field work within the limits of the mapped area. In the summer of 1890 something over two months were spent in the southern and western portions of the field. With the assistance of M. R. Campbell, a somewhat detailed survey was made of the more complicated areas and the conclusions of previous seasons were re-examined and verified.

A very considerable change in the methods of work has taken place since the season of '87. This change was the natural and necessary adaptation of methods to the special conditions under which work had to be carried on in this region. The method first employed was to measure with great accuracy a few lines across the country in a northwest-southeast direction at intervals of about ten miles. It was believed that these would afford ample data for determining the structure and stratigraphy of the region. It soon became evident, however, that work would have to be done along the strike between the measured lines since otherwise most important facts of structure were overlooked. In 1888 the stadia transit with which the earlier lines had been measured was discarded and the geologic data was placed directly upon the topographic map, a few lines being measured with plane table to obtain data for the stratigraphic column. In 1890 the method was still further modified by discarding the plane table and plotting all lines in the note book. The distances are obtained by recording the revolutions of the buckboard wheel or by pacing, and the directions taken from a hand compass are laid down by means of a small horn protractor. The great advantages of this method are rapidity of work, compactness of results, and ease with which previous work is referred to at any time. As much ground can be covered while making such a survey as if only verbal notes were taken; the work of several weeks is contained in a small note book instead of a large number of loose plane table sheets; and finally with the observations constantly before him and in their proper relations the geologist is able to work out in the field details of the problem presented without waiting for the reduction and plotting of data in the office. The admirable points of this graphic method of field work were shown in its application to some of the highly complicated regions as that between Weisner and Indian mountains, or along the fault line north of Coosa river.

Relation to the Work of other Geologists.—From its position along the southern border of Tennessee, much valuable information as to the geology of this region is contained in Safford's classic work, "The Geology of Tennessee." Safford's report, however, is less detailed in regard to the southern part of Tennessee than it is in regard to the central and northern portions of that state, so that only in a broad way can the descriptions be applied to northern Alabama and Georgia. The work of the Alabama geologists on the other hand, has been largely on the southern limit of the Appalachian province along the line where the Paleozoic and crystalline rocks pass under the Mesozoic and later formations. The work done by State surveys in northwest Georgia previous to 1887 was of so fragmentary and superficial a character that it amounted to little more than a reconnaissance.

The region is thus practically a virgin field and occupies a specially important place as the connecting link between the work of Tuomey and Smith in Alabama and Safford in Tennessee. It is also a representative region including as it does all the Paleozoic formations of the southern Appalachians, characteristically developed and types of all the more important forms of Appalachian structure, with some which, so far as our present information goes, are unique.

Scope of the Report.—The scope of the report is general rather than special and detailed. The aim has been to adapt it to the needs of the laymen rather than the professional geologist. It is not intended as an exposition of the mineral resources of the country, but rather as a discussion of the physiography of a limited area with special reference to the origin of the natural features and their relation to the geologic structure. It is hoped, however, that it may furnish information which will serve as a basis for the economic geology of the region, and that it may render intelligible many apparently disconnected and anomalous facts which the observant layman, as well as the prospector and miner, is constantly meeting.

II. LOCATION AND AREA OF THE REGION MAPPED.

The region under consideration extends from longitude 85° to 86° 30′ and from latitude 34° to 35°, forming a rectangular area 85 miles from east to west, and 70 from north to south. The rectangle includes a narrow strip a little less than a mile wide along the southern border of Tennessee. Of the remainder, two-thirds or 3880 square miles, are in Alabama, and one-third or 1940 square miles are in Georgia. In Alabama it embraces Jackson, DeKalb and Cherokee counties and portions of Madison, Marshall, Blount and Etowah; and in Georgia, Dade, Walker, Catoosa, Chattooga and Floyd, with portions of Whitfield, Gordon, Bartow and Polk.

The area is covered by six atlas sheets of the U. S. Geological Survey topographic base map, viz: The Ringgold and Rome sheets lying mostly in Georgia, and the Stevenson, Fort Payne, Scottsboro and Gadsden sheets in Alabama. The accompanying map was compiled from the above named atlas sheets reduced to one-third the original scale, or to very nearly six miles to one inch. The surface elevations are represented by the lines printed in brown called contours. Thus the heavy brown line indicates the position at which a horizontal plane just 1000 feet above sea level would intersect the land surface. This heavy brown line is called the "thousand foot contour." In many places there is a lighter brown line between the heavy one and the streams; this marks the position at which a horizontal plane 750 feet above sea level would intersect the surface, and it is called the "seven hundred and fifty foot countour." The latter plane would be everywhere 250 feet below the one whose intersection with the land surface is marked by the thousand foot contour. Hence the vertical height represented by two adjacent contours is 250 feet; or in other words, the contour interval is 250 feet.

III. TOPOGRAPHY.

Topographic Divisions.

The area covered by the accompanying map falls naturally into three divisions, each characterized by a different type of geological structure and a peculiar topography or surface configuration.

Every feature of a landscape is due to the action and interaction of natural forces. Sometimes the process by which the present form was reached may be traced, and at others it is so complicated as to render this impossible. In regions having a simple geologic history, that is, in which the forces have acted uniformly and always in the same direction, the forms of the surface are seen to be the direct result of processes still in operation. Such a region is the one under consideration. Since its final elevation above the level of the sea in which its rocks were deposited as sediments it has probably never been resubmerged, and while the elevation may have made several halts in its progress it has been fairly continuous. The marks of a fluctuating rise are but slightly if at all manifest.

The chief factors that determine the forms into which the streams will carve a land surface are; first, the angle at which the rocks are inclined to the horizontal, and, second, the difference in hardness between the different beds. Horizontal rocks tend to produce plateaus, and inclined rocks tend to produce ridges. Especially is this tendency manifest where there is an alternation of hard and soft beds, or rather, where there is great diversity in the ability of different beds to resist erosion. The relations between topographic forms on the one hand and geologic structure on the other, will be further discussed in describing the topography of the region.

The three topographic divisions above referred to are: (1) the western, embracing the area northwest of Browns valley; (2) the central, embracing Sand and Lookout mountains with the adjacent valleys; (3) the eastern, embracing the country to the southeast of Lookout mountain.

Topography of the Western Division.

Plateaus or Mesas.—In the western division the rocks are practically horizontal, having only a very slight inclination to the southwest. The topography is that always produced by horizontal beds of varying hardness which have been raised somewhat above sea level so that eroding agents have opportunity to work. It is a typical plateau region. In the plateau regions of the Far West are many elevations with flat tops and steep sides which have been carved from horizontal rocks by stream erosion and left as isolated remnants of an originally continuous plateau. To these elevations the term "mesa" is applied and it may be well to apply the same term to the exactly similar topographic forms of northern Alabama. The mesas all reach nearly the same altitude, about 1,600 feet above sea level. Their broad, level tops show them to be the remnants of a plateau which once extended continuously over the whole of this division and far to the west and north. The remnants of this plateau now occupy only about one sixth of the area within this division of the map, and a still smaller proportion farther west. The rock originally covering the whole region, but now found only as a capping upon the summits of the mesas, is the heavy sandstone forming the base of the coal measures. Below this, which is called the Lookout sandstone, the rocks are largely calcareous for a thousand feet or more. Thus the sandstone rests upon an insecure foundation. As soon as the streams cut through to the calcareous beds, their progress downward is rapid and they readily sink their channels to near the level of the Tennessee river which drains the region. Since the cap rock is more durable than that forming the lower slopes of the ravines, the latter is worn away most rapidly, undermining the capping sandstone. It results from these conditions that the mesas are bounded by cliffs of sandstone below which are steep limestone slopes, usually deeply covered with sandstone debris. When the whole of the protecting sandstone cap has been thus undermined and removed the surface assumes a wholly different character. Low rounded hills or a gently undulating plain replace the mesa with its abrupt slopes and level top.

The heavy mantle of vegetation covering the surface conceals in a large measure the characteristic topographic forms which are so well displayed in arid and treeless regions. Back from the immediate edge of a mesa there is nothing in the gently undulating or level surface to indicate that one is on the top of a mountain.

Topography of the Central Division.

Synclinal Mountains.—The second topographic division, as already stated, embraces Sand and Lookout mountains, forming a broad belt with nearly parallel sides extending northeast and southwest through the central portion of the map. The division is traversed throughout its entire length by Lookout and Wills valleys, separating the two mountains. Near the lower edge of the map the northern extremity of Murphrees valley, known as Bristows cove, interrupts the broad level top of Sand mountain toward its eastern side, while McLamores cove forms a similar deep notch in the northern end of Lookout mountain.

Sand and Lookout mountains are not, strictly speaking, plateaus, though they closely resemble them in many respects. The rocks are not horizontal, but in each case dip gently toward the center, forming broad, shallow troughs. Sand mountain is much the broader and shallower of the two, and hence approaches more nearly to the plateau type. Lookout mountain is narrower and appears, especially toward its southern end, as a deep trough, with high, well defined sides. Both of these mountains resemble the mesas of the western division in their sandstone cliffs with the steep limestone slopes below.

Anticlinal Valleys.—Browns valley properly belongs in the central division and falls in the same category with Murphrees, Wills, Lookout and Chattanooga valleys. All of these are directly dependent on the geological structure and since that is the same in every case are remarkably like in form. The rocks forming the mountains dip away from the *edges* toward the center, while the rocks underlying the valleys dip away from the *center* toward the sides. In other words they are anticlinal valleys. Browns valley passes entirely through the map area, but each of the others named terminates within it in a cove. The anticlinals which determine the position of the valleys, after continuing for long distances, suddenly die out and the rocks instead of forming an arch become horizontal and then merge into the synclinal. At this point the valley terminates in a huge amphitheatre encircled by high sandstone cliffs. The process by which these remarkable valleys were formed will be more fully explained in describing the drainage.

Topography of the Eastern Division.

The third topographic division lies to the southeast of Lookout mountain. Its general surface is but little above the level of the larger streams, though it is interrupted by a number of ridges rising to a considerable elevation, the highest reaching two thousand feet above sea level. There is much greater complexity of geologic structure than in either of the two divisions previously described, and in consequence there is much greater complexity in topographic form.

Monoclinal Mountains.—The ridges are formed by the outcropping edges of hard beds of sandstone which generally dip toward the east or southwest. Some of them extend for long distances with remarkable uniformity in trend and elevation. They are usually unsymmetrical; one side, the face of the ridge, being steep and rugged, while the other, the back, has a smooth and gently ascending surface. This difference is caused by the position of the sandstone beds as shown, for example, in figure 1, which is an east and west section through Armuchee valley. The elevation represented in profile at T is Taylors ridge and its western side is formed by the broken edges of the sandstone, while the eastern slope coincides very nearly with the dip of the beds.

The difference in slope between the face and back of the ridge becomes less with an increase in the dip, and where the rocks approach the vertical the ridge is symmetrical. This form is shown in the same section Figure 1, by the elevation D which represents Dicks ridge.

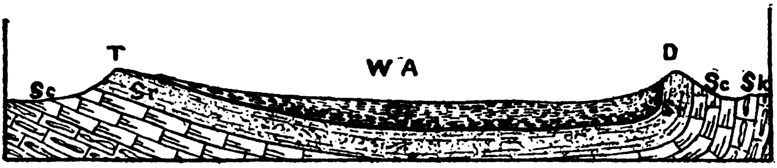


Figure 1. Section from Dicks ridge D, through West Armuchee valley W A, and Taylors ridge T; showing *unsymmetrical* and *symmetrical* ridges depending on the *dip* of the *strata.*

The ridges northwest of the Coosa valley are produced by the sandstone of the Rockwood formation, and form a group with similar characteristics, while the most of those south of the Coosa valley are formed by Cambrian sandstone. The latter are less uniform and continuous in character. The principal ridges, Weisner and Indian mountains, are comparatively short, tapering off rapidly in either direction from a culminating point near their central portions.

Flatwoods.—A marked topographic feature of this division is the Coosa valley. The Coosa river from Rome southwest to the edge of the map at Gadsden swings back and forth across the broad level valley that has been cut in the soft calcareous shales and limestones of the Cambrian. The actual flood plain is not extensive and the highly contorted shales are generally exposed along the banks of the river. The country back from the alluvial flood plain is poorly drained and heavily timbered, and to this the term "flatwoods" is applied. While most of the flatwoods districts are underlain by Cambrian shales they are not confined to that formation. A considerable area north and west of Rome in the Oostanaula valley is underlain by Carboniferous shales but retains all the characteristics of typical flatwoods.

Chert Hills.—It remains to speak of one other type of surface largely represented in the southwestern part of this division and also to the west of Taylors ridge. In the lower portion of the Silurian is a great thickness of magnesian limestone or dolomite containing large quantities of silica in the form of chert or flint. The outcrops of this formation, the Knox dolomite, are marked by heavy deposits of residual materials left by the solution of the carbonates. These residual materials, consisting of red clay and chert, cover broad areas forming a series of low rounded hills without apparent regularity. The underlying rock seldom appears at the surface. There are few small streams since the water which falls upon such an area is absorbed by the layer of porous residual material and reappears in springs at the edge of the outcrop.

IV. DRAINAGE.

Streams of the Western Division.

The region under consideration is about equally divided between the drainage basins of the Tennessee and Coosa rivers with a small area in the southwestern corner in the Black Warrior basin. The larger part of the western topographic division lies in the great bend of the Tennessee river. The arrangement of its streams is for the most part approximately radial. They flow from the high land along the Alabama-Tennessee line southeast, south, and southwest to the nearest point of junction with the river.

Formation of Limestone Valleys.—The fact that the valleys of this section are underlaid by limestone has already been mentioned as well as the method by which they were formed, in describing the intervening sandstone-capped mesas. The readiness with which this limestone is dissolved gives the streams a very different character from those flowing over sandstone or other rocks which must be worn into small fragments and carried away by the stream. When that is the case the stream can not lower its bed faster than it can carry the material away, and in order to carry any considerable amount it must have sufficient fall to give its water the necessary velocity. If the rock over which the stream flows is such that it can easily be ground up into mud or fine sand, then a moderately swift current will carry it along; but if it forms coarse gravel or bowlders a steep descent and swift current are required to do the transporting. Hence a stream flowing over rocks which have to be carried away as mud, sand or gravel cannot erode its bed below a certain level, depending on the size of the fragments which it is compelled to carry. With a stream flowing over rocks which may be dissolved, however, it is very different. A swift current is not necessary to carry off the material which is held in solution, but the most sluggish current is just as efficient as a more rapid one. Hence the lowering of the bed of the stream is not limited but continues until the valley is nearly as low as the mouth of the stream. Beyond this, of course, it can not go, since it must have some descent. A stream which is no longer deepening its channel is said to be at *base level.* This is the condition of the streams of this western division. Excellent examples are Flint river and Paint Rock river. Both have reduced their channels almost or quite to the base level of the Tennessee river and their currents are very sluggish, not rapid enough to remove sand and gravel though sufficient to remove the limestone by solution. The head branches of these rivers, rising upon the sandstone capped mesas have a very rapid fall, since most of the descent from these high levels to the level of the Tennessee valley is confined to a few miles at their source.

Streams of the Central and Eastern Divisions.

Consequent Streams.—The radial arrangement of the streams which characterizes the region in the great bend of the Tennessee river, like the plateau topography, is possible only in regions having horizontal or but slightly inclined strata, for where the strata are highly inclined they influence the course of the streams and compel them to flow in certain definite directions. This is seen in the drainage of the central and eastern divisions which is wholly different from that of the western. The streams are *consequent*, that is, their courses are dependent on the geologic structure being determined by the dip of the strata and the relation of hard and soft beds. A consideration of the manner in which the streams have carved the surface of the land into the present form will make clear this relation between the dip of the strata and the present position of the stream channels. It is true that this process has been an extremely slow one, and the change produced in a single generation is almost imperceptible. But careful study shows that every year the agents at work accomplish a little, and if sufficient time is given they are fully competent to produce the greatest results.

Examining the map it will be seen that the streams of the central division do not meander over the surface in an indefinite way with broad curves such as are seen, for example, in Paint Rock river. If a straight line be drawn from the head of Wills creek to the point where it leaves the valley west of Attalla, it will be seen that the stream does not deviate a mile from this line on either side in flowing a distance of nearly fifty miles. For a shorter distance the course of Little Wills creek is even nearer to a straight line and almost exactly parallel with that of the larger stream. Black creek, Little river, Chattooga river and West Chickamauga creek all show similar rectilinear and parallel courses. Now why does Wills creek pursue such a remarkably direct course for this great distance, and why are the courses of Little Wills and Black creeks almost exactly parallel with it? These questions can be answered by considering the history of these streams from their beginning to the present time.

Formation of Anticlinal Valleys.—It must be remembered that the rocks of the region, which will be described later, were all laid down in horizontal beds upon the sea bottom. Sometimes the sea was deep and limestones were formed; at other times it was shallow and the shore was near by, when mud and fine sands were spread out by the currents to form shales; and finally the surface on which deposits were being made stood for a long time very near the sea level, sometimes a little below it, receiving layers of mud and sand, and sometimes far enough above it to support a luxuriant vegetation whose remains are found in seams of coal. But during all this time there were no stream channels. Or if any were formed while the surface was above sea level they were obliterated by the first layer of sand deposited when the surface was again submerged. Finally the surface emerged from the sea for the last time, and then the ancestors of the present streams were born. The first drainage was determined by the inequalities of the rising surface, and these where doubtless in the form of gentle undulations parallel with each other and extending in a northeast and southwest direction, the beginnings of the present anticlinal and synclinal folds. Thus a long low ridge with gently sloping sides and rounded top occupied the present position of Wills valley. Toward the north it died out between the points of two similar ridges which occupied the positions ef Deer-head and McLamores coves. West of Sand mountain was a still longer ridge of the same character where Browns valley now is and east of Lookout mountain was a somewhat shorter but broader ridge in the place of Broomtown valley. Between these ridges which occupied the position of the present valleys were broad shallow depressions, the present mountain summits; that is, the original relation of high and low land has been exactly reversed. How did this come about?

Water falling upon this surface would naturally flow down from the sides of the ridges into the broad shallow depressions between, and collecting into larger streams would flow off in the direction in which the trough happened to slope. The slope of the troughs in this particular region was toward the southwest so that there must have been a stream rising upon the slopes of the ridge which then occupied the position of McLamores cove and flowing southwest through the whole length of the Lookout mountain trough. Another stream rose north of the edge of the map and flowed southwest in the Sand mountain trough. This was the first stage in the development of the drainage system and the probable condition of things may be represented by figure 1, plate I, in which the position of the stream originating in the Lookout mountain synclinal trough is indicated as B–B, and that in the Sand mountain trough as T–T. Into these two main streams the small side streams, l, l, l, and s, s, s, flowed in opposite directions from the top of the intervening anticlinal ridge.

At first these streams were all flowing upon the same kind of rock, probably coarse sandstone, so that they were able to erode their channels most rapidly where the fall and consequently the transporting power of the stream was the greatest. But the slope of the synclinal troughs was very slight so that the main streams had little power to deepen their channels while the side streams flowing into them from the intervening ridge, although they were much smaller, still by reason of their greater fall eroded their beds more rapidly.

If the rocks of this region had been uniform in character for a long distance down from the surface, the effect of the more rapid cutting of the side streams would have been simply to reduce the height of the intervening ridge, leaving the main streams in their original position in the synclinal troughs. But the rocks are not homogeneous. They consist of alternating hard and soft beds and after the side streams had cut down a few hundred feet they came to layers of shale and then limestone which they could remove much more rapidly than the overlying sandstone. As soon as a side stream reached these soft rocks at any point it tended to widen its valley at that point by removing the soft rocks so as to undermine and thus break down the overlying harder beds. By a continuation of this process lateral valleys were formed, figure 2, plate I, extending in the direction of the ridge and at right angles to the side streams.

This may be regarded as the second stage in the development of the drainage system, and be represented by figure 2, plate I.

The two streams *w* and *w'* cut away at the divide *d* and the stream *w* having the lowest outlet was able to erode more rapidly than *w'* and so pushed the divide nearer and nearer toward the side stream *l'* till finally it tapped the latter and led its waters off by way of *l*. The lateral stream thus formed (*w w*, figure 3, plate I.), was the beginning of the present Little Wills creek. The same process would have continued till this stream had tapped successively all the drainage basins above if it had not encountered a second hard bed through which erosion was very slow. After the soft rocks were removed which lay above this hard bed, then the same process was repeated which had taken place on the original anticlinal ridge; that is, side streams with greater fall were able to cut through the hard bed more quickly than the main stream and reaching soft rocks below began to widen their valleys and then form lateral valleys at those points. The same process was repeated with this second set of lateral streams. By erosion at the divides, D, D′, D″, etc., figure 3, plate I, that one having the lowest outlet tapped the drainage basin of the one adjacent and led its waters off along the axis of the anticlinal. The side stream W, (figure 3, plate I.) possessed a great advantage over any of the others in having a much lower outlet and hence it was able to encroach upon them and divert their headwaters to its own channel. But with each conquest of new territory, by the additional volume of water thus gained, it became more efficient in eroding its valley while the streams whose drainage basins had been thus diminished were even less able to hold their own. Thus the process was cumulative in its effects and finally the stream last formed became the dominant one of the drainage system.

This process by which the ridge was removed and the streams shifted from their original position in the synclinal trough to the axis of the anticlinal may be further illustrated by the diagram, figure 2, representing a section through the ridge and adjacent troughs. The heavy line represents the present surface and the unbroken lines the beds of rock as they exist at present, below the surface. The curved, dotted lines represents the position of the beds as they originally existed before their removal. Two of these beds, Cl and Sr, which are sandstone, offer much greater resistance to erosion than the limestones Cb, Sc and Sk. The upper curved line

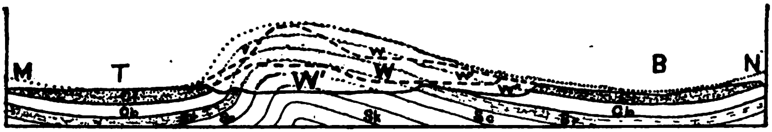


Figure 2. Section through Lookout mountain, Wills valley and Sand mountain; showing profile of the land surface at four stages in the development of the present drainage system.

represents the profile of the land surface on which drainage originated, corresponding in position to the line M N in figure 1, plate I. B and T indicate the position of the main streams in the synclinal troughs into which the side streams flowed from the intervening anticlinal ridge. As already explained the first point at which the upper hard bed Cl was cut through was on the steep slopes of this ridge as at w and v, where the lateral valleys were subsequently formed in a direction parallel with the ridge. The upper broken line, then, will represent the surface at the second stage of its development represented in figure 2, plate I. Continuing to erode their channels downward through the soft rocks Cb, the streams encountered the second hard bed Sr, and the process above described was repeated, producing the surface represented by the lower broken line. This is the third stage in the development of the drainage system in which the streams had the positions indicated in fiure 3, plate I. Finally the lateral stream which started at W, being already through the two hard beds, easily distanced its competitors and robbed them of successive portions of their drainage area until it became the dominant stream of the system, Big Wills creek.

The stream, BB, figure 1, plate I, which originally flowed the whole length of the Lookout synclinal trough, was not permitted to retain that position. Robbed of all its western tributaries by the process above described, it was unable with its diminished volume to lower its channel sufficiently fast for its own protection. At a point on the eastern side of the synclinal a stream, RR, figure 3, plate I, has cut back from the valley of the Coosa and diverted the upper portion from its original channel. Hence the present course of Little river, figure 4, plate I., follows the synclinal to this point and then turns sharply to the southeast by a deep rocky gorge. Other portions have been more recently diverted by Wolf and Yellow creeks. Thus the stream which originally drained the whole of the synclinal trough and the slopes of the adjacent anticlinal ridges has been robbed of the greater part of its drainage basin and Black creek alone, a mere remnant of the original stream, retains the course which it has followed from the beginning. For a short time, during the stage represented by figure 3, plate I., Little Wills creek, w w, was the encroaching stream, but reaching a hard stratum its career of conquest was checked and the stream W, more favorably situated, although last born, became the dominant stream of the system. In the meantime the anticlinal ridge had been entirely removed and in its place a deep valley excavated, while the original stream channels were left high up in the synclinals now forming the tops of the mountains.

This is but one of numerous examples in this region which might be followed out in detail to show how the drainage system has adjusted itself to the structural surface and how the present position of the streams is dependent on the dip of the strata and the alternation of hard and soft rocks.

It must be borne in mind, however, that only the latest stages in the development of the present topography can be followed with certainty. The condition which immediately preceded the present is easily inferred but as the processes are followed backward they become more obscure and finally are only to be conjectured. Hence in the development of Wills valley as it has been sketched above, the explanation becomes more largely pure hypothesis as the more remote stages are reached. The explanation offered for the earliest stages is not the only one possible, but is perhaps the most probable of a number which might be given.

Also in the above sketch several complicating factors have been purposely omitted for the sake of greater simplicity in presenting the essential points of the theory. Thus the anticlinal arch probably continued to rise during the process of erosion and the effect which this may have had on the resulting topography has not been taken into consideration.

Again, the faults which occur at frequent intervals along the western side of Wills valley must have exerted an important influence, since along the fault line the rocks are fractured and crushed so that they afford less resistence to erosion than elsewhere.

The date of the inception of these faults would also have a bearing on the problem, and their influence on the course of development of the valley would be one thing if they were formed near the beginning of the folding and quite another if formed after erosion had made some progress.

This uncertainty as to details, however, does not affect the general theory of the formation of anticlinal valleys. The most important feature of the theory is the encroachment of one stream upon the drainage basins of those adjacent, and this rests upon evidence wholly free from the doubt above indicated.

V. STRATIGRAPHY.

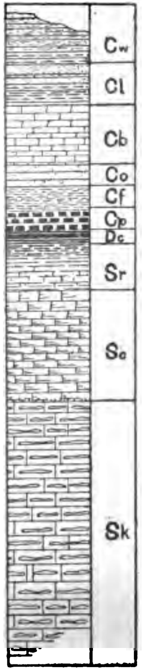
General Classification of the Rocks.

The rocks of the area under consideration belong wholly to the Paleozoic system and include representatives of all its larger subdivisions or periods. None of them have undergone metamorphism to any considerable extent. The western limit of the metamorphic rocks lies a short distance to the east of the area. There is much doubt as to the horizon to which these metamorphic rocks belong and this can only be determined, if at all, by much further detailed study; but with regard to all the rocks within the map area there is no serious difficulty in determining at least approximately their proper stratigraphic position.

The formation names employed are such as avoid all remote correlations, being purely geographic and taken from localities within the area described or in contiguous areas from which they have been continuously traced. The basis of division is a lithologic one, a *formation* being a group of strata which clearly belong together by reason of their general similarity in composition, implying a uniformity in the conditions of sedimentation during their deposition.

The accompanying table shows the subdivisions made within the area and also the names which have hitherto been applied to the same rocks by Smith and Safford. Wherever changes have been made from the usage of these geologists it has been in accordance with the general principles of nomenclature above stated:

PERIOD NAMES.			Formation names and symbols used in this Report.	NAMES HITHERTO APPLIED TO THE SAME ROCKS.		
				Smith: Geology of the valley region adjacent to the Cahaba coal-field, 1890.	Smith: Outline of the Geology of Alabama, 1878.	Safford: Geology of Tennessee, 1869.
Carboniferous.	Coal measur's	Cw, Cl.	Walden sandstone. Lookout sandstone.	Coal measures.	Upper coal measures Lower coal measures Millstone grit; Conglomerate	Coal measures.
	Missis-sippian.	Cb.	Bangor limestone	Bangor limestone	Upper sub-carboniferous, or mountain limestone	Mountain limestone.
		Co.	Oxmoor sandtone	Oxmoor sandstone and shales		
		Cf.	Floyd shales.			
		Cp.	Fort Payne chert	Fort Payne chert	Lower sub-carboniferous	Siliceous group.
Devonian.		Dc.	Chattanooga black shale	Black shale	Genesee or Black shale	Black shale.
Silurian.		Sr.	Rockwood formation	Red mountain or Clinton.	Clinton or Dyestone	Dyestone group: Whiteoak mountain sandstone, Clinch mountain sandstone.
		Sm.	Rockmart slate		Cincinnati or Nashville	Nashville.
		Sc.	Chickamauga limestone	Trenton or Pelham limest.	Trenton, chazy or maclurea	Trenton or Lebanon maclurea limestone.
		Sk.	Knox dolomite	Knox dolomite	Quebec or Knox dolomite	Knox dolomite.
Cambrian.		Cc.	Connasauga shale	Choccolocco or Montevallo shales		
		Cr.	Rome sandstone		Knox shales	Knox shale.
		Cw.	Weisner quartzite	Weisner quartzite	Calciferous or Knox s. s.	Knox sandstone.
		Ca.	Coosa shale	Coosa shales	Potsdam or Chilhowee	Chilhowee sandstone.



PERIOD NAME.	STRATIGRAPHIC COLUMN.	THICK- NESS.	FORMATION NAME.	TOPOGRAPHIC FEATURES.
CARBONIFEROUS.	C_w	500+	Walden sandstone.	Level or rolling plateau summits.
	Cl	60-600	Lookout sandstone.	Cliffs and steep slopes.
	Cb	320-800	Bangor limestone	Mountain slopes and valleys.
	Co	0-380	Oxmoor sandstone. . . .	Terraces on mountain slopes or low ridges.
	Cf	0-340	Floyd shale.	Narrow valleys.
	Cp	140-300	Fort Payne chert.	Narrow sharp ridges parallel with the mountain escarpments.
Devonian	Dc	20-60	Chattanooga black shale	
SILURIAN.	Sr	170— —650	Rockwood format'n	
	Sc	800— —1400	Chickamauga limestone.	Level valleys.
	Sk	2000— —2500+	Knox dolomite.	Irregular rounded hills.

Figure 3. Columnar section showing the character and relative thickness of the strata exposed west of Broomtown valley.

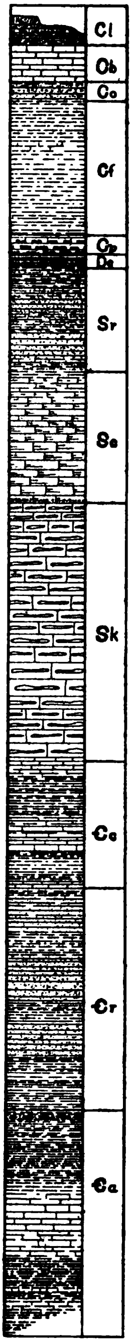
PERIOD NAME.	STRATIGRAPHIC COLUMN.	THICKNESS.	FORMATION NAME.	TOPOGRAPHIC FEATURES.
CARBONIFEROUS.	 Cl	200–300	Lookout sandstone	Cliffs and steep slopes.
	Cb	300–500	Bangor limestone.	Steep mount'in slopes and valleys
	Co	0–250	Oxmoor sandstone.	Low ridges.
	Cf	1200— —1600	Floyd shale........	Broad level valleys.
	Cp	50–210	Fort Payne chert	
Devonian	Dc	0–50	Chatta. black shale.	
SILURIAN.	Sr	870— —1600	Rockwood format'n	High steep ridges.
	Sc	1100— —1800	[Rockmart slate.] Chickamauga limestone.	Valleys and low'r slopes of ridges
	Sk	3000— —3500	Knox dolomite ..	Low irregular hills and ridges.
CAMBRIAN.	Ꞓc	1600— —2000	Connasauga shale..	Narrow valleys.
	Ꞓr	2000— —3500	Rome sandstone... [Weisner quartzite]	Comby ridges. High irregular ridges.
	Ꞓa	3000+	Coosa shale.......	Broad level valleys. "Flatwoods."

Figure 4. Columnar section showing the character and relative thickness of the strata exposed east of Broomtown valley.

In the following pages the several formations will be taken up in order, beginning with the oldest, and described with reference to their (1) lithologic character, (2) areal distribution, and (3) topographic features.

Cambrian Rocks.

The oldest rocks in the area under consideration belong to the Cambrian period. They are divided into three formations, as follows:

3. Connasauga shale; calcareous gray shale with beds of oölitic limestone at the bottom, and blue seamy limestone toward the top.
2. Rome sandstone; variegated sandy shale and thin bedded red and brown sandstone, including the Weisner quartzite in lenticular beds.
1. Coosa shale; calcareous shales with beds of limestone; also calcareous and siliceous nodular concretions.

The above subdivision of the Cambrian rocks is based wholly upon their lithologic character, and all correlation with other regions is purposely avoided. It must be regarded however, as only tentative, since a thorough study of the fossils contained in these rocks will doubtless necessitate considerable changes. Mr. C. D. Walcott has reached the conclusion from very recent study of fossils collected by Dr. Cooper Curtice, that most, if not all the rocks embraced in the above named formations, belong to the Middle Cambrian. Mr. Walcott is also inclined to regard some of the rocks along the northwestern side of Coosa valley which are included with the Coosa on the accompanying map, as equivalent to the Connasauga shale. But further study, both of the fossils and the structure of Coosa valley, will be required to decide this point.*

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* The stratigraphic succession from the Connasauga shale downward through the Rome sandstone into the Coosa shale has always been considered without break or unconformity. The very different physical appearance of the two shale formations with their interbedded limestones made this the natural interpretation and one would hesitate to pronounce them equivalent except on the clearest evidence. Since the accompanying

Coosa Shale.—**C**c. To the lowest division of the Cambrian rocks the name Coosa shale has been applied from the locality where it is best developed, the Coosa valley between Rome and Gadsden.

The typical Coosa is a finely laminated shale, greenish, yellowish or gray in color, weathering to a heavy gray soil. The shale generally contains beds of limestone, though it may be locally free from any large amount of calcareous matter. These beds of limestone form the most striking characteristic of the formation. In thickness they vary from several feet forming nearly the whole mass, to less than an inch with thick bands of shale intervening. Frequently in place of continuous beds the shale is filled with flat limestone concretions about half an inch in thickness and a few inches broad with irregular rounded outlines. These concretions are arranged in regular layers separated by from one to three inches of shale, and projecting from the shale surface along the banks of streams, present a characteristic appearance which readily distinguishes the formation. In

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map was prepared and this report sent to press, however, additional field work has been done which throws light on the question and adds the weight of structural evidence to the conclusion suggested by Mr. Walcott after a study of the fossils that the Connasauga and Coosa shales occupy the same stratigraphic position. A careful study of the region north and south of Rome, Ga., revealed the presence of an extensive fault immediately west of the belt of Rome sandstone by which the shales above the sandstone are repeated so as to appear conformable to and below it. Some small areas of Knox dolomite were found along the fault line dipping under the Rome sandstone; and for the first time beds of oolitic limestone, always considered characteristic of the Connasauga, were found in the shales heretofore called Coosa. It is probable that other faults parallel with the first, but whose existence has not been so clearly proven, cause the Connasauga shale to be several times repeated in such a manner as to extend entirely across the Coosa valley. The striking differences in physical appearance of the Connasauga and Coosa shales are probably to be accounted for by secondary changes in the latter, brought about by the folding and faulting to which they have been subjected in a much higher degree than the former. The differences may be due in part to different conditions of deposition such as nearness or remoteness of shoreline. Unfortunately the cessation of field work will delay for the present the working out of details of structure and stratigraphy in this extremely interesting region.

other parts of the formation similar shaped concretions are abundant, but composed of silica instead of lime. These siliceous concretions accumulate on the surface and very closely resemble deposits of water-worn gravel.

The shales are almost always highly contorted, and the limestone beds are filled with a reticule of white calcite veins, while the limestone itself is usually dark blue in color. No reliable estimate can be formed as to the thickness of the Coosa, but from the broad area covered, even allowing for the contortion which it has undergone, it must be at least several thousand feet.

The Coosa shales, and indeed all the Cambrian rocks, are confined to the division east of Lookout mountain, although a little further south they have a much greater westward extension in Jones and Murphrees valleys.

The largest area occupied by the Coosa shale is the Coosa valley between Rome and Gadsden. The length of this belt within the map area is about forty miles, and for twenty-five it has a breadth of ten miles. Approaching the eastern end, it tapers off into a numbr of long slender fingers, being separated by a fault from the younger rocks on the north. This fault will be described later. After a slight break at Rome, the same belt continues northeastward to the edge of the map, forming the valley of the Oostanaula river. The western edge which is limited by a fault as further south, is very irregular and several projecting arms extend toward the west where they lie upon rocks which belong much higher in the series.

Areas of Coosa shale are generally characterized by the type of surface known as "flatwoods." A large proportion of the rock material is removed by solution and the soft shales remaining offer but little resistance to eroding agents. The residual soil is a cold, stiff clay, poorly adapted to cultivation and hence is largely permitted to retain its native forest growth.

Rome sandstone and Weisner quartzite.—**C**r. Above the Coosa shales is a group of sandy shales, sandstones, and quartzites of undetermined but variable thickness. The name of the formation is taken from its typical development at Rome, though it shows wide variations from this type both in thickness and lithologic character.

The base of the formation consists of several hundred feet of highly indurated greenish sandy shale. This is always contorted with much crushing and the breaks are partially filled with veins of quartz which are seldom more than half an inch thick. Above this layer of greenish sandstone is a great thickness of sandstones generally thin bedded and frequently passing into sandy shales. They are usually purple or reddish brown in color and show abundant suncracks and ripple marks. The upper part of the formation consists of shales frequently highly colored in alternating bands of red, purple, yellow, chocolate and green. It is impracticable to separate these shales from the sandstone on account of their intimate intergradation. By a very gradual decrease in the proportion of sand the formation changes from sandstone to shale with no abrupt break in the transition. It also changes along the strike so that while some sections show the sandstone extending nearly to the top of the formation, others not far distant show it composed almost entirely of shale.

Among the purple sandstones are occasionally intercalated beds of white sandstone or quartzite, from a few feet in thickness to many hundred. It is called the Weisner quartzite, from its typical development in Weisner mountain. This quartzite has hitherto been correlated with the Potsdam of New York and the Chilhowee of Tennessee, but although it resembles both of these formations in lithologic character, there appears to be no sufficient ground for assuming that they are contemporaneous deposits. Especially is the name Chilhowee objectionable, since the rocks which have been classed together under that name appear from the work of Willis and Keith in Tennessee to belong to several widely separated horizons. The Weisner quartzite probably does not occupy an invariable position in the Cambrian series, but may occur at any point, within certain limits, having been produced by the rapid local accumulation of pure sand contemporaneously with the slower deposition of sandy mud which formed the Rome sandstones. Hence the Rome sandstone and the Weisner quartzite are not regarded as distinct formations, but as different lithologic types of the same, due to local differences in the condition of sedimentation.

In the Cambrian areas of Chattooga valley the Rome formation is either wholly wanting or represented by fine shales which have not been separated from the overlying Connasauga. If the formation contains sandstones in this region they have not yet been uncovered by erosion. To the east of Taylors ridge the formation is represented by a belt of purple and brown sandy shales with only occasional beds of true sandstone. Apparently growing more sandy toward the southeast, the Rome reaches its greatest development along the eastern border of the Oostanaula-Coosa valley.

The distribution of the Weisner quartzite is quite circumscribed. It occurs strongly developed in only two localities, at Weisner mountain and a few miles to the eastward at Indian mountain, both on the southern edge of the map. There is a profound fault between the two and it is possible that they originally formed a continuous bed, but on this point there is at present but little evidence available. It is quite probable that they are wholly distinct local developments of quartzite at different horizons in the formation They form the northern members of a series of similar lenticular quartzite masses which extend to the southwest nearly to the southern limit of the Paleozoic rocks.

The Rome formation produces a series of comby ridges varying in height with the proportion of sandstone and shale and its degree of induration, but always sufficient to form a strong contrast with the flatwoods country of the adjacent Coosa shales. The many knobs and short ridges north and south of Rome are good types of the topography resulting from the weathering of these rocks.

The Weisner quartzite is the most obdurate rock of the region, and wherever developed in any force, forms bold ridges steep and rugged on the side formed by outcropping edges of quartzite and sloping more gradually with the dip of the beds on the other side.

Connasauga Shale.—**C**c. Above the Rome sandstone is another series of shales and limestones forming the upper division of the Cambrian rocks as they occur in this region. The formation is named from its typical development in the Connasauga valley of northern Georgia. It corresponds in general with the Knox shale as described by Safford. The formation consists of gray calcareous shales alternating with beds of limestone. The limestone is most abundant toward the top where it frequently occurs almost entirely replacing the shale for several hundred feet in thickness. It is separated into thin beds by seams of argillaceous material which are scarcely visible on fresh surfaces, but become prominent by weathering, since the lime is dissolved away leaving behind the insoluble clay forming the seams. There is no sharp line separating the shales from the beds of limestone, but one passes into the other by insensible gradations. Wherever the clay seams increase slightly in thickness and number the rock weathers to a bed of shale, and when they decrease it appears as a bed of limestone.

The lowest beds of limestone which mark the base of the formation have a peculiar oölitic structure. The rock is largely made up of small round grains the size of bird shot. Sometimes these grains or oölites are flattened or elongated. They are wholly different in their orign from the rounded quartz grains of which sandstones are composed. The latter have been rounded by the action of water in streams or waves rubbing them against each other and so wearing off their corners, but the grains of the oölitic limestone were formed in their present position in the rock itself though the process by which they were formed is not thoroughly understood.

The Connasauga forms a long narrow belt in Chattooga valley, extending toward the north beyond the limits of the map. At the southern end of this strip this upper division of the Cambrian is brought in contact with the Coosa by a fault. Where the two shale formations come together it is difficult to draw a line between them and some of the shales on the western side of Coosa valley may be found to be Connasauga instead of Coosa as they are represented on the map. The Connasauga forms a long narrow strip bordering the Rome which lies east of Taylor's ridge and a still more extensive strip parallel with the Rome sandstone which has already been described as bordering the Oostanaula-Coosa valley. At no point west of Lookout mountain has erosion cut deep enough to expose these rocks, though probably they do not lie far below the surface in Wills valley.

The Connasauga shales invariably give rise to valleys lying between the more obdurate Rome sandstone on the one hand, and rounded hills of residual clay and chert on the other. When the limestone makes up a considerable proportion of the formation, these valleys have a deep red soil, as in the case of Van's valley, north of Cave Spring, Georgia. When the argillaceous shales predominate the soil is apt to be rather sterile.

Silurian Rocks.

The rocks of the Silurian period are divided into three formations, as follows:

3. Rockwood formation. On the northwest calcareous shales, becoming sandy shales and coarse sandstones toward the southeast.
2. Chickamauga limestone. On the northwest blue limestone, becoming argillaceous in the upper part toward the southeast.

1. Knox dolomite. Massive, cherty, magnesian limestone, becoming sandy toward the southeast.

Knox dolomite.—Sk. The lowest of these formations is the Knox dolomite of Safford. It is usually a rather coarsely crystalline, sugary, magnesian limestone, though it is sometimes compact and fine grained resembling lithographic stone. The color is generally light gray, but varies all the way from white to dark blue. The chief characteristic of the formation is the large amount of silica which it carries, mostly in the form of chert, though sometimes disseminated throughout the mass as glassy siliceous grains, in which case the product of weathering is a coarse porous sandstone. The chert occurs in layers of flattened nodules which are frequently banded parallel to the outer surface. The nodules pass into continuous beds and in some cases these beds of chert make up the larger portion of the rock with but little calcareous matter intervening. The formation is between 3,000 and 3,500 feet in thickness, thinning slightly toward the south.

The Knox dolomite occupies long narrow strips in the central and eastern portions of the map area. It comes to the surface along the anticlinal axes, or as a narrow strip on either side when the Cambrian rocks are exposed along the center of the anticlinal. The largest area of dolomite is in the southeastern portion where these rocks form a broad gently undulating synclinal.

The weathering of the Knox dolomite gives rise to a characteristic topography. The carbonates of lime and magnesia are removed by solution, and there is left behind a large amount of insoluble clay and chert. The surface, deeply covered with this residual material, bears few running streams. Large numbers of sink holes receive the water falling on the surface, and from these it finds its way through caverns dissolved in the rock itself, emerging at length in springs along the borders of the adjacent formations. The surface is covered with a series of low rounded hills without any apparent regularity of arrangement, except that corresponding with the outcrops of the dolomite. When the chert forms the greater part of the rock mass, greater regularity in arrangement results, and high steep ridges are formed in place of rounded hills. This is apt to be the case also, where the dolomite has a very steep dip.

Chickamauga Limestone.—Sc. The second division of the Silurian, lying next above the Knox dolomite, is the Chickamauga limestone. The name is taken from the Chickamauga valley, where the formation has its greatest development within the map area, and is intermediate in character between its western and eastern phases. The formation includes the rocks classed as Nashville or Cincinnati, Trenton and Chazy by Smith, and as Nashville and Trenton or Lebanon by Safford. Whatever correlations or subdivisions may be made, based on the evidence of fossils, the formation from top to bottom is essentially a lithologic unit. It is, in its western exposures, a blue, flaggy, highly fossiliferous limestone, with some local variations of minor importance. From the eastern edge of Lookout mountain, there is a gradual and uniform change toward the southeast. The change consists in a decrease in the abundance of fossils and calcareous material, and an increase in argillaceous matter; the limestone becomes more earthy and along the eastern edge of the map area is red or dove colored and sparingly fossiliferous. In its unweathered condition it is still essentially a limestone, but by the leaching out of the calcareous matter it usually appears at the surface as an earthy non fissile shale.

In the southeastern corner of the sheet the Chickamauga is differentiated into two well marked formations. The lower portion retains much the same character that it has toward the west being a rather massive blue limestone with some beds which weather to shale. The upper portion, however, is composed of calcareous shale which by the development of a very perfect cleavage forms the Rockmart roofing slate.

In the southern part of the area the base of the Chickamauga is locally marked by a heavy bed of breccia, composed of angular or slightly rounded fragments of chert. In some places the bed is made up almost wholly of these chert fragments, with but little cement, and it shows all gradations from this extreme to a fine grained earthy limestone containing only occasional fragments scattered through its mass. When there is just sufficient calcareous material to make a firm cement or bedding for the angular chert fragments, the rock is used for mill stones for which purpose it seems admirably adapted.

This bed of breccia points to a period of disturbance at the conclusion of the Knox dolomite epoch when the rocks already deposited were elevated sufficiently to suffer some local erosion with the redeposition of the more durable portions. No indication of unconformity appears between adjacent beds ot dolomite and limestone, but in their present disturbed and poorly exposed condition, a slight unconformity would be extremely difficult to detect.

The largest areas of Chickamauga limestone are in the southern half of Browns valley and in West Chickamauga valley. In the former it is the oldest formation exposed, occupying the top of an anticlinal; in the latter it is the youngest, occupying a synclinal from which the higher formations, still seen in Pigeon mountain,have been removed. Aside from these comparatively broad areas, the Chickamauga limestone occurs only in narrow strips where the upturned edges of the formation border the various synclinals occupying the central and western divisions of the map area.

This limestone uniformly gives rise to valleys which usually lie between the chert hills on one side and the Rockwood shale or sandstone ridge on the other. It generally extends well up in the face of the ridge, protected from erosion by the overlying sandstone.

Rockwood Formation.—Sr. This formation includes all of the Silurian above the Chickamauga limestone; the Dyestone group, White Oak and Clinch mountain sandstone of Safford, and the Clinton, Red mountain or Dyestone of the Alabama survey.

In the northwestern portion of the area, the formation consists of from 600 to 800 feet of calcareous shales with thin beds of limestone and fossil iron ore. Toward the southeast it becomes less calcareous and more sandy. In Taylor's ridge it is about double the above thickness and appears as a series of thin bedded purple sandstones, corresponding to Safford's White Oak mountain sandstone. Still farther east in Chattoogata and Rocky Face, interbedded with shales above the red sandstone, are two heavy beds of white sandstone or quartzite, corresponding in lithologic character though probably not in stratigraphic position to Safford's Clinch sandstone. This change from the phase presented in Browns valley to that in Rocky Face, is a gradual one and doubtless with sufficient exposures individual beds could be shown to pass through all the intermediate varieties. It is exactly the change which would be expected to occur in passing from off-shore deposits to those comparatively near the source of supply from which the rock material was derived. While this change in lithologic character is most marked in passing across the strike, it is also noticeable along the strike. Thus in Johnsons Crook at the head of the Wills valley anticlinal the formation is very calcareous, while to the southwest on the same anticlinal at Atalla it contains much thin bedded sandstone. The same transition is seen in Taylors ridge. At its northern extremity, White Oak mountain in Tennessee, the formation consists largely of thin red sandstones, with shales toward the top containing a considerable bed of iron ore. Toward the southwest the shales and iron ore at the top disappear and the whole formation at the southern end of the ridge consists of heavily bedded reddish brown sandstone with some beds approaching quartzite in character. These lithologic changes indicate that the structure axes are not exactly parallel with the Silurian shore line, but that the latter had a more east and west direction than the present strike.

The Rockwood formation nowhere occupies areas of any considerable extent, but the aggregate area of its outcrops is not inconsiderable. The red iron ore which renders this formation so important in the southern Appalachian region, does not extend south of the Tennesse line in Taylors ridge and probably does not occur in any of the ridges east of Dirt Seller mountain. It is uniformly present to the west, though not always in quantities sufficient for profitable working. In the central division the formation occurs in narrow strips forming minor ridges along the sides of the valleys and parallel with the escarpments of Coal-measure sandstone. The ridges are produced partly by the rocks of this formation, but are due more to the resistance offered to erosion by the chert beds at the base of the Carboniferous. In the eastern division the Rockwood sandstone produces the ridges, the cherty beds being a subordinate factor.

Devonian Rocks.

Chattanooga black shale —Dc. The whole of the Devonian period is represented in Alabama and Georgia by a thin stratum, from eighteen to thirty-five feet, of black, highly carbonaceous shale. This passes by a more or less gradual transition into the blue and yellow shales of the Rockwood formation below, while at the upper limit there is an abrupt passage to the Fort Payne chert forming the base of the Carboniferous. The upper bed of the Chattanooga, about three feet in thickness, is bluish gray shale, and usually carries at the top a layer of round concretions an inch or less in diameter.

Occurring between two ridge making formations, the black shale occupies a narrow strip along one side near the crest of the Rockwood ridges. It occupies this position in all except the extreme eastern ridges, where the formation appears to be wanting, the Fort Payne chert resting directly upon the Silurian sandstone

Carboniferous Rocks.

The rocks of the Carboniferous period are placed in the following six divisions, of which the two upper belong to the Coal-measures and the remainder to the sub-Carboniferous group, as defined by Smith and Safford. The name, Mississippian, has more recently been applied to this group of rocks by Prof. H. S. Williams and is much preferable to sub-Carboniferous. The four formations comprised in the Mississippian group in this region are not separated on the accompanying map, but are represented together by a single pattern in order to avoid confusion.

6. Walden sandstone; coarse sandstone, sandy shale, argillaceous shale or fire clay, and beds of coal.
5. Lookout sandstone; coarse conglomerate, sandstone and shale with beds of coal toward the north.
4. Bangor limestone; blue crinoidal limestone with nodules of chert, partly replaced toward the southeast by the two formations below.
3. Oxmoor sandstone; white or yellow coarse porous sandstone, occurring as lenses at the top of the following formation.
2. Floyd shale; black carbonaceous shale with beds of shaly limestone.
1. Fort Payne chert; cherty limestone with beds of massive chert at the base.

Fort Payne chert.—Cp. The lowest formation of the sub-Carboniferous or Mississippian group consists of highly siliceous limestone. Its name is taken from Fort Payne, Alabama, where it is typically developed. At the base of the formation are heavy beds of chert which become less massive higher up, and toward the top are replaced by more or less abundant isolated nodules. Sometimes the chert is almost wholly replaced by beds of porous sandstone. This change is specially marked toward the northeast.

The Fort Payne chert varies in thickness from two hundred feet in the southern portion of the field, to fifty or or less in the northeastern. The lower beds carry few fossils, but higher up they become very abundant and the rock frequently consists of a mass of crinoid stems imbedded in a siliceous cement. On weathering, the cement remains as a porous chert filled with fossil impressions.

The topographic value of the Fort Payne chert has already been described in discussing the relative efficiency of that formation and the Rockwood in the production of ridges.

Oxmoor sandstone.—Co. }
Floyd shale.—Cf. } The Fort Payne chert is followed by an extremely variable formation which has been named from its great development in Floyd county, Georgia. It consists in the eastern division of black or yellow shales with beds of limestone, and local developments of sandstone. In the central and western divisions it is much thinner and more calcareous, and only towards the south are the sandstones present. The Floyd shales contain a large amount of calcareous matter, either as beds of pure blue limestone or disseminated through the shales. The fossils are confined to the more calcareous portions and in these they are extremely abundant. As already stated, the formation becomes more calcareous toward the west and contains heavy beds of limestone below the Oxmoor sandstone which there forms its upper member.

The Oxmoor sandstone is variable in character and in its position in the formation. Toward the southwest it is a coarse, porous sandstone, white or yellow, occurring in heavy beds with few fossils. East of Taylors ridge there is a thin bedded, more compact sandstone, sometimes highly fossiliferous which passes gradually into the Floyd shales above and below. Indeed, these sandstones east of Taylors ridge may be regarded simply as a phase of the Floyd shales, and it is questionable whether they should be correlated with the Oxmoor sandstones occurring west of Browns valley.

Wherever the Oxmoor sandstones occur they exert a marked influence on the topography. In Texas and Dirt Town valleys they appear as low but distinct ridges lying between the higher elevations formed by the Fort Payne chert and Rockwood on one hand, and the escarpment of Lookout sandstone on the other. West of Browns valley and south of the Tennessee river, the Oxmoor sandstone forms a terrace part way up the steep slopes of the plateau. The

Floyd shales always give rise to valleys forming in the eastern division, a continuation northward of the broad, level Coosa valley "flatwoods." In the central division they are long and narrow, lying between the short ridges and the sandstone escarpment. The underlying rock is seldom exposed, being usually deeply covered by overplaced soil and rock dèbris from the formations on either side, especially from the Lookout sandstone.

Bangor Limestone.—Cb. The upper member of the sub-Carboniferous or Mississippian group consists in the main of pure blue limestone. Its greatest development is in the western division of the area, where it rests directly upon the Oxmoor sandstone; or where that is wanting as at Stevenson, Ala., the limestone extends without break down to the Fort Payne chert. It is equivalent to Smith's upper sub-Carboniferous, and very nearly to Safford's mountain limestone. The limestone is always highly fossiliferous, being made up almost entirely of fragments of Crinoid stems. A short distance, perhaps fifty feet, from the top it becomes very earthy and usually passes into bright colored clay shales. These beds mark the transition from a deep sea in which the limestone formed, to a shallow sea in which the mud, sand and pebbles of the formation above were deposited.

In the western division the Bangor limestone forms the slopes of the mesas already described in speaking of the topography of that section. The larger streams have cut down through this formation, but it still forms the bottoms and sides of the smaller valleys. Wherever the protecting cap of sandstone remains, the slopes are steep, rocky, and usually covered with a dense growth of cedar. Where the sandstone has been entirely removed, a gently undulating surface results. In the central division the Bangor limestone is found only in the steep mountain slopes. It is not, itself, a mountain producing formation, but owes its position to the protecting sandstone which overlies it. In the eastern division the formation is much thinner and greatly restricted in the area which it covers. It is only found skirting the few remnants of Lookout sandstone which have here escaped erosion.

The thickness of the Mississippian group as a whole, increases from the northwest to the east and south. At Stevenson, Alabama, it is not more than eight hundred feet in thickness. At Guntersville it is from eight hundred and fifty to one thousand feet. In the central division it increases from eleven hundred feet at Trenton, Georgia, to about fifteen hundred at the southern end of Lookout mountain. The Floyd shales of the eastern division are so highly contorted that their thickness can not be estimated with any degree of certainty, but this formation alone must be as thick as the whole group further west.

Walden Sandstone.—Cw. }
Lookout Sandstone.—Cl. } *Coal measures.*—While the lower portion of the Carboniferous period is represented by rocks which are prevailingly calcareous, the upper portion is represented by sandstones and shales with very little calcareous matter, indicating a marked and permanent change in the conditions of deposition at the end of the Mississippian era. The change was in the direction of shallower water and more abundant supply of mud and sand, conditions unfavorable for the animals whose remains go to form limestone. The surface also stood above sea level at various times, long enough at least for the luxuriant vegetation to flourish which has left its remains in the coal beds.

These sandstones and shales above the Mississippian group form the coal measures. They have been carefully studied by geologists of the Alabama Survey, especially McCalley and Gibson, and the coal beds which they contain have been so fully described that only their general stratigraphic relations will be mentioned here.

These rocks are divided in the present report into two formations, Lookout sandstone below and Walden sandstone above. The division is made at the top of a bed of conglomorate from ten to seventy feet in thickness which is a constant feature throughout the greater part of this field.

The Lookout sandstone consists of argillaceous shale or fire clay, sandy shale and sandstone with conglomorate at the top. The formation varies in thickness from about four hundred feet in Lookout mountain to less than fifty feet in Bristows cove, where the conglomorate rests directly on the Bangor limestone. In its thicker portions the Lookout contains at least two seams of coal which are in places of work able thickness, though not generally so.

Above the conglomorate are sandstones and shales with beds of coal and fire clay forming a series of rocks very similar to those composing the Lookout. These upper rocks, embraced under the name Walden, are more homogeneous than the Lookout and show marks of fewer abrupt changes in conditions of sedimentation. They contain most of the coal which forms so important an element in the wealth of northern Alabama. West of the Tennessee river only a few traces of conglomerate are found and the division between the Lookout and Walden becomes very uncertain.

While the greater part of Coal-measure rocks which originally covered the whole area have been removed by erosion, their present outcrops still occupy a much larger part of the surface than those of any underlying formation. In the western division, as already stated in speaking of the topography, mere remnants of a once continuous sheet of these rocks remain capping the summits of the mesas.

Of the central division at least three-fourths are covered by Coal-measures. The beds of conglomorate and associated heavy sandstones usually form a vertical cliff which is a prominent feature in the plateau escarpments, and an almost impassible barrier about the edges of Sand and Lookout mountains and the mesas west of Brown's valley. The Walden sandstone lying above the conglomorate occurs in the synclinals of Sand and Lookout mountains.

In the eastern division there are three very limited areas of Coal-measure rocks. These are fragments which have been protected from erosion by their position in the lowest portions of the Taylors ridge synclinal. They are of great interest as proving beyond question that the Coal-measures originally extended in a continuous sheet over the whole area. Thus they afford a measure of the thickness of strata eroded, especially in the eastern division, since the region was elevated above sea level.

The marked difference in the character of topography produced by the Coal-measures on the one hand and the Rockwood formation on the other, is due to the relation which the two sets of rocks ordinarily hold to a horizontal plane. The Rockwood sandstones usually dip at steep angles and so produce sharp ridges. The Coal-measure sandstones, on the other hand, are usually horizontal or have low dips, and produce forms of topography approaching the plateau type. In a few cases, the topography of the two formations is reversed. Thus, in the northern end of Dirt Seller mountain, the horizontal Rockwood forms a small plateau, while toward the southern end of Sand mountain, and in the southern end of Lookout mountain, the highly inclined Coal-measures form sharp monoclinal ridges.

VI. STRUCTURE.

Folds.

General Relations.—In the region under consideration the rocks whose beds now stand at all possible angles with the horizon, were originally horizontal or nearly so. They were deposited in broad sheets of sand or mud over the bottom of a sea which covered the greater part of the Mississippi valley, having its eastern shore a little to the eastward of the present great Appalachian valley. Since their deposition, the strata have been subjected to compression in a northwest and southeast direction so that the beds originally horizontal are now crowded into a series of folds. If the rocks which have been removed by erosion were restored, a fluted surface would be presented, formed by parallel arches and troughs extending in a direction at right angles to that in which the compression took place. The accompanying map covers but a very small part of the area occupied by these folded strata in the Appalachian province. They form a narrow belt extending toward the northeast through Tennessee, Virginia and Pennsylvania, and southwest toward middle Alabama.

The forces which caused these folds acted in such a manner as to produce the greatest results in the beds which were deposited near the shore. On the southeastern edge of the compressed belt, east of Chattooga valley on the map, the folds are closely crowded together and no considerable areas of horizontal rocks remain. In the central portion between the Tennessee and Chattooga rivers these folds are further apart, their sides have gentler slopes, and the beds are still horizontal in the troughs. On the extreme western edge the force appears to have spent itself, and the strata retain very nearly the horizontal position in which they were originally deposited. They have been raised to a higher level with reference to the sea and slightly warped but are without sharp folds.

Definition of terms.—In describing these folded strata the term synclinal is applied to the trough, and anticlinal, to the arch. A synclinal axis is a line running lengthwise of the synclinal trough, at every point occupying its lowest part and toward which the rocks dip on either side. An anticlinal axis is a line occupying at every point the highest portion of the anticlinal arch, and away from which the rocks dip on either side. These axes may be horizontal or inclined. Their departure from the horizontal is called the pitch of the axis and is usually but a few degrees.

The anticlinal folds of the southern Appalachians are rarely symmetrical for the rocks usually dip away from the axis much more steeply on one side than the other. The accompanying section, figure 5, across Lookout mountain and Wills valley to Sand mountain, shows the typical anticlinal and synclinal fold of this region. The dotted lines represent the form which the strata would have if all the rocks removed by erosion were restored; while the heavy lines represent beds which remain, and the present land surface. *S* and *A* indicate the positions of the synclinal and anticlinal axes.

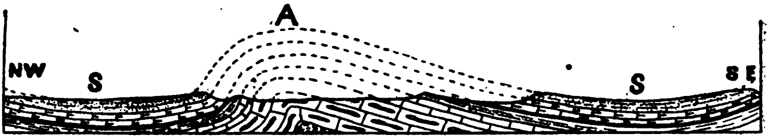

Figure 5. Section through Lookout mountain, Wills valley and Sand mountain; showing the normal form of *unsymmetrical anticlinal fold* with steep dips on the north-western side.

It is to be observed that the steeper dips are along the northwest side of the anticlinal axis. This is the general rule to which there are but two exceptions within the map area. These exceptions are in Bristows cove, at the head of Murphrees valley, and at Rising Fawn, at the head of Wills valley. In these two cases the steeper dips are on the east side of the anticlinal axes. The latter of these exceptions is only local, and the anticlinal assumes its normal form a few miles to the southward. The Murphrees valley anticlinal, however, has the steeper dips on the eastern side of the axis to its extreme southern end.

Structure of the Western Division.—As already stated in describing the topographic features, the strata west of Browns valley are practically horizonal. This region has, therefore, the simplest possible geologic structure. This is shown in the left hand portion of the structure section which accompanies the map. It must not be understood that the horizontality is absolute, for the sediments were not laid down on a perfectly level surface, and the lifting to their present position has been accompanied by slight warping of the beds and a general tilting to the southwest. These deviations from the horizontal, however, are small and scarcely to be detected except by following the same bed for a long distance.

Folds of the Central Division.—The first marked disturbance of the rocks met with in coming from the northwest along the line of the structure section is at the western edge of Browns valley where the strata are sharply upturned and in some places broken by a fault which will be described later. Passing Browns valley the rocks which form its steep and frequently precipitous eastern border are found to dip from 5° to 8° to the southeast, forming the western edge of the Sand mountain synclinal. This escarpment extends in a nearly straight line across the map, with a trend of N. 40° E. Turning 10° more to the north about the Tennessee line, it extends for sixty-five miles further as the western escarpment of Waldens ridge facing upon the Sequachee valley. These are the structural continuations, respectively, of Sand mountain and Browns valley. The southwestern extension of this escarpment beyond the map area is only eight or ten miles to the vicinity of Blountville, where it loses its distinctive character. Its entire length is thus about 150 miles. The escarpment is not continuous throughout this distance for numerous streams flowing from the broad top of Sand mountain have cut canyons back some distance from the edge, forming deep notches in the cliff line.

Throughout the greater portion of the map area Sand mountain extends as a single broad synclinal but in both the southern and northern portions it is more complicated. Thus in the southwestern corner of the map the synclinal is divided into two distinct synclinals by the northern end of the Murphree valley anticlinal. This latter extends seventeen miles from the edge of the map, where it disappears, and north of this point the two synclinals merge in one. Of these two synclinals the one to the west is broad and shallow, while that to the east, lying between Bristows cove and Greasy cove, is narrow and the strata forming its sides dip steeply toward the center. The latter continues southwestward as the Blount mountain synclinal. Instead of forming a flat topped mountain as is ordinarily the case, the Coal-measure sandstones are here bent down to the valley level in the center of the synclinal, while along its edges they form high, sharp, monoclinal ridges. A similar break in the regularity of the Sand mountain synclinal occurs where it crosses the Georgia--Alabama line. The relations of the folds in a small area embracing portions of Sand and Lookout mountains with the adjacent valleys is shown in figure 6. The heavy lines extending in a northeast and southwest direction indicate the position which the axes of the folds occupy. The arrows show the direction in which the strata dip and the lines toward which they point are synclinal axes, while those away from which they point are anticlinal axes.

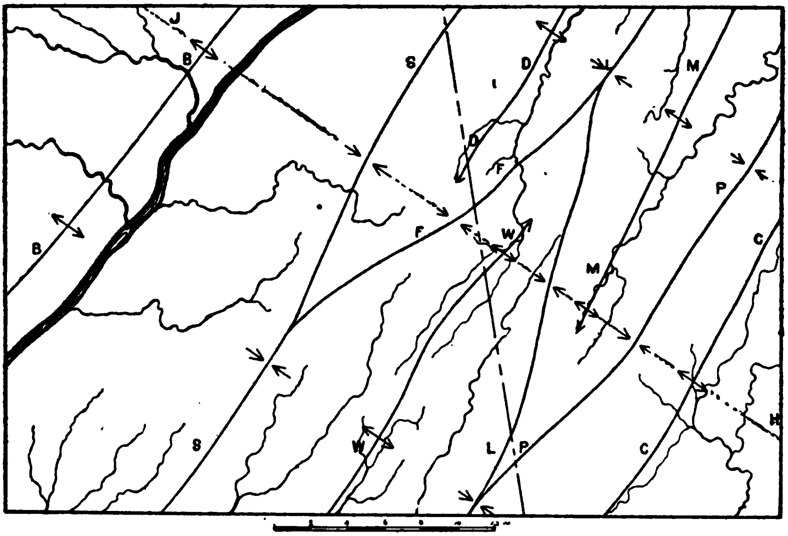

Figure 6. Outline map of a portion of the region between Chattooga valley and Browns valley; showing the relation of *synclinal* and *anticlinal axes*. Arrows indicate the direction in which the strata dip. B B indicates the position of the Browns valley anticlinal axis; S S Sand Mountain synclinal; D D Deerhead cove anticlinal; F F Fox Mountain synclinal; W W Wills valley anticlinal; L L Lookout Mountain synclinal; M M McLamores cove anticlinal; P P Pigeon Mountain synclinal; and C C Chattooga valley anticlinal axes.

The Lookout valley anticlinal D D, figure 6, coming in from the north terminates in Deerhead cove, very much as Murphrees valley does in Bristows cove. It divides the Sand mountain synclinal into two, a very broad one on the west and a narrow one on the east. The latter forms Fox mountain just west of Rising Fawn. The axis of the Fox mountain synclinal, F F, figure 6, continues toward the northeast as the axis of the northern part of Lookout mountain, L L figure 6. The overlapping ends of the three anticlinals, DD, WW, and MM, figure 6, give rise at this point to a series of four synclinals, SS, FF, LL, and PP, figure 6, arranged in a zigzag fashion like the letter **W**. The structure section, figure 7, further illustrates the relation of the folds along the dotted line in figure 6, at right angles with

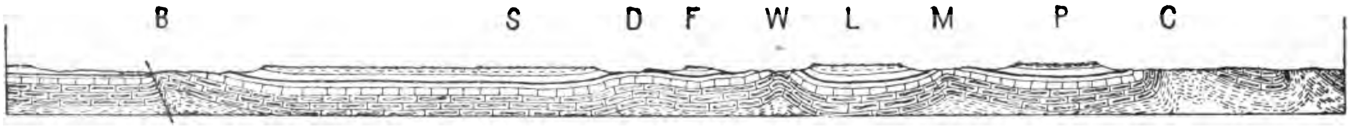

Figure 7. Section from Chattooga valley to Browns valley along the line J H in figure 6; showing the relation of *synclinal* and *anticlinal axes* B indicates the position of Browns valley anticlinal axis; S Sand Mountain synclinal; D Deerhead cove anticlinal; F Fox Mountain synclinal; W Wills valley anticlinal; L Lookout Mountain synclinal; M McLamores cove anticlinal; P Pigeon Mountain synclinal; and C Chattooga valley anticlinal axes

the axes. The position of the latter are indicated by the same letters used for corresponding axes in figure 6. The section shows the three overlapping anticlinals as described above and the four resulting synclinals which form Sand, Fox, Lookout and Pigeon mountains, lettered respectively S, F, L and P.

The narrow Fox mountain synclinal between Johnsons Crook and Deerhead cove has been cut through by the waters of Lookout creek, so that Wills and Lookout valleys appear to be continuous, but structurally they are entirely distinct.

Lookout mountain lies almost wholly within the map area, terminating about a mile north of its northern limit. Its southern end is cut sharply off by a fault running from Gadsden to Attalla. At this point the synclinal is sufficiently deep to bring the Walden sandstone down to the level of the Coosa valley. The strata in the upturned edges of the synclinal form high ridges, steep on the outer side and sloping gently within toward the center. The axis rises gradually toward the north and the dips becoming less steep the two ridges coalesce and form the level topped mountain which is its prevailing character throughout the greater part of its length. From the southern end, the synclinal gradually increases in width toward the north from about two miles, at Gadsden, to nine, where it crosses the Alabama-Georgia line. At this point the synclinal is divided into two by the anticlinal of McLamores cove; the eastern axis, continuing in line with the southern part of the mountain, runs through Pigeon mountain, while the western, bending slightly toward the north unites with the axis of the Fox mountain synclinal and forms the northern end of the mountain which terminates abruptly in Lookout point just south of Chattanooga.

Folds of the Eastern Division.—Between Lookout mountain and the Oostanaula-Coosa river a number of synclinals and anticlinals occur. They are less regular than those already described and the folds are more closely crowded together. Along the western side of the anticlinal axis the strata are frequently overturned and faulting is a much more important factor than in the central division.

The rocks which here resist erosion and so form the high ridges are no longer the Walden and Lookout sandstones, but belong to the Rockwood formation in which, as already described, the proportion of sandstone to shale and limestone increases rapidly toward the southeast.

First north of the Coosa river are the Dirt Seller mountain and Gaylors ridge. These are both synclinals terminating in abrupt spoon-shaped points toward the north. From these high points the sides of the synclinals diverge toward the southwest, the axes pitching down in that direction. On the south they are sheared off by faults which cut across at angles from 45° to 60° with their axes. In each case a triangular area is thus included by the two arms of the synclinal and the fault.

East of the Chattooga valley lies Taylors ridge extending a long distance northward into Tennessee, where it is called White Oak mountain. This ridge, so remarkable for its uniformity in elevation and trend, forms the western side of a synclinal whose eastern edge is very irregular and in many places entirely absent by reason of faulting.

This synclinal is not a smooth, regular trough like those already described but is broken up into a number of small basins by anticlinal folds which cross from one side to the other. Thus Dirt Town valley and West Armuchee valley are separated by a ridge transverse to the main synclinal axis. In the gap cut through the ridge by Ruff creek, its anticlinal character is perfectly shown. A similar transverse anticlinal separates Houston valley from the northern portion of the synclinal. Dirt Town valley and Texas valley may be regarded as parts of the same synclinal, separated as described above by a transverse anticlinal. In this case, however, the anticlinal has been lifted higher and a valley eroded for some distance along its axis. Thus it is similar to the other cases, but carried to a further stage of development. This transverse anticlinal forms Simms mountain but does not pass entirely across the synclinal as in the other cases, the axis pitching down and dying out before reaching the eastern side. In a similar manner the axes of Lavender mountain coming from the southwest and Johns mountain from the north, pitch down and carry the ridge-making sandstones below the valley level. There is thus formed a natural gateway for the passage of the streams draining the interior of the synclinal basins and through this flows Armuchee creek.

East of the above described synclinal is a series of four overlapping ridges, each one advancing a few miles further to the northward than its western neighbor. They are formed by the zigzag outcrop of a fluted surface, the axes of whose folds pitch toward the south. The northern ends of the ridges are all synclinal, though by the lesser prominence of the eastern sides of the synclinals they appear to be monoclinals dipping to the southeast. Thus the western side of a synclinal and its continuation south as the eastern side of an anticlinal forms Johns mountain. Horn mountain has the same structure, except that it terminates to the south in two anticlinals. Mill creek and Chattoogata mountains are but repetitions of the structure seen in the others.

Excepting the region about Weisner and Indian mountains the structure southeast of the Oostanaula-Coosa river is comparatively simple. The greater part of this area is occupied by a broad gently undulating synclinal composed chiefly of Knox dolomite. Radiating from Rome with a fan-like arrangement a number of minor folds along the western edge bring the underlying Cambrian shales to the surface. The axis of this broad synclinal pitches gently to the southeast and in the corner of the map the rocks appear which overlie the dolomite, namely, Chickamauga limestone and Rockmart slate. This synclinal extends only a few miles east and south of the limits of the map to a fault which marks its contact with the semi-metamorphic rocks. The Knox dolomite in this region is extremely massive and the force which in other places compressed the strata into close folds here produced only gentle undulations.

A small area in the vicinity of Weisner and Indian mountains shows greater complexity of structure than any other portions of the map area. The complexity, however, is produced rather by faulting than folding, and the region will be described later.

Faults.

Definition and Classification of Faults.—In most regions where the strata are elevated to any considerable extent above the position in which they were originally deposited, the process of elevation has been accompanied by more or less fracture. Such fractures are called *faults* when the rocks have slipped past each other on opposite sides, and the plane on which the slipping takes place is called the *fault plane.* The angle at which a fault plane intersects the vertical is called the *hade*, and the amount of vertical displacement which any bed suffers is the *throw* of the fault. In regions whice have simply been elevated without lateral compression, faults, almost without exception, hade to the downthrow; that is, the fault plane dips under the rocks which have been relatively depressed. This is usually called the *normal fault.* The accompanying ideal section, figure 8, illustrates the simplest form of the normal fault. The arrows indicate the direction in which the strata on opposite sides of the fracture have been moved, and the line, FF, which indicates the position of the fault plane, dips under the rocks which have been depressed. It will be seen by consideration of the section that the lateral extent of the rocks is greater after than before the faulting, and hence we should not expect to find this taking place as the result of

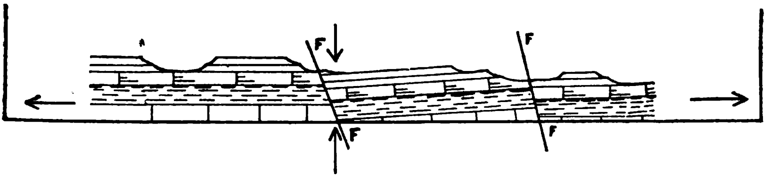

Figure 8. Ideal section through flat strata; showing the character of *normal faults*. The fault plane F F dips under the strata which have been relatively *depressed*.

lateral compression, the effect of which is to crowd the rocks into smaller space than they originally occupied.

In describing the Appalachian folds it was shown that they are usually unsymmetrical, the dips being steeper on one side than on the other. In the formation of such a fold, when the rocks on the steeper side of the anticlinal become nearly vertical, a plane of weakness is developed along which fracture is especially liable to occur. This plane cuts across the strata on the steeper side of the anticlinal and is inclined so as to be nearly parallel with the gentler dips on the other. If the lateral compression which produced the fold is continued, a break may occur along this plane of weakness. Such a break is called a *thrust fault*, and is peculiar to compressed regions like the one under discussion. The hade of such a fault is always toward the up-throw; that is, the fault plane, T T, figure 9, dips under the rocks which have been relatively elevated. Hence, the lateral extent of the strata is less after than before the faulting. These thrust faults always occur on the steep side of the anticlinal and since this is generally on the west side, so most of the faults of this region are on the west side of anticlinals and the east side of synclinals.

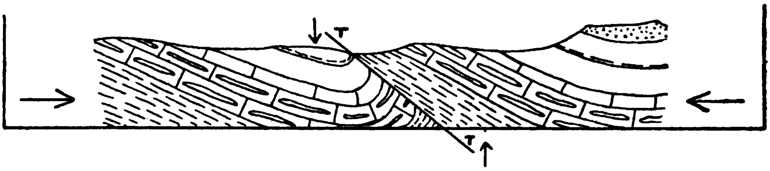

Figure 9. Ideal section through folded strata; showing the character of *thrust faults*. The fault plane T T dips under the strata which have been relatively *elevated*.

Thrust faults may be classed, for convenience of description, in two groups according to the angle of hade; (1) those in which the fault plane makes an angle of less than 45° with the vertical, and (2) those in which it approaches the horizontal. The first group in which the fault plane is rather steep comprises the larger number but the same fault, in different portions may belong to both. There is no essential difference between the two, both being produced by the same forces acting under slightly different conditions.

The *over thrust* or *displacement* is the distance between the broken edges of any stratum on opposite sides of the fault plane or the distance through which the rocks have been pushed on the fault plane. It may be slight, only sufficient to conceal a few beds of rock, or it may be very great, so as to completely obliterate the steep side of the contiguous synclinal and anticlinal, and leave the gentler dipping sides of two anticlinals resting conformably one upon the other. The greatest displacement is found in faults which have their fault planes nearly or quite horizontal. In these the displacement is sometimes several miles.

The *stratigraphic displacement* is measured by the thickness of the strata which normally occur between beds brought by the fault into contact at the surface. For example, if a fault should bring the base of the Knox dolomite in contact with the top of the Chickamauga limestone the stratigraphic displacement would be equal to the combined thickness of Knox and Chickamauga or about 4,700 feet. Like the overthrust, this stratigraphic displacement is variable in amount. In some cases it involves only part of a single formation, and in others where the oldest and youngest formations are in contact it is measured by the combined thickness of the whole stratigraphic column, amounting to many thousand feet.

Wills Valley Faults.—Some excellent examples of thrust faults are found in Wills valley and one of the most typical will be described in detail. Wills valley has already been described as a long, narrow, deeply eroded anticlinal lying between the broad, shallow synclinals which form Sand and Lookout mountains. Except for a short distance at its northern end it has the normal form of an unsymmetrical arch with the steep side to the northwest. The dips are from 10° to 18° on the southeast and 75° to 90° on the northwest sides of the arch. At various points along the western side of this normal anticlinal are found thrust faults of greater or less extent.

It may be well to indicate briefly how the presence of a fault is determined in the field. It must not be imagined that where the strata have been thrust up hundreds or thousands of feet on one side of a fracture, the surface remains higher than on the side where they have been relatively depressed an equal amount. Erosion has planed down the surface so that all the inequality produced by faulting is obliterated. Indeed, it is not probable that the difference in elevation on opposite sides of the fault line was at any time very great. The probability is rather that the process was so extremely slow, consisting of so many small slips distributed over so long a time, that erosion kept pace with elevation and the two processes balanced each other. Nor is it often possible to detect the plane on which the slipping took place, although it may sometimes be seen, especially when the displacement is slight. The ordinary evidence of a thrust fault is the finding of formations in contact which are normally separated by a greater or less thickness of intervening strata. Hence a fault is more marked the greater its stratigraphic displacement since more widely separated formations are thus brought in contact at the surface.

Thus, to return to Wills valley, there is a regular sequence in the formations and topographic features in passing from the center to either side wherever the anticlinal holds its normal form undisturbed by a fault. This sequence is the same on both sides of the axis. The center of the valley is occupied by a strip of Knox dolomite forming low rounded hills composed of chert and residual clay. On either side of this central dolomite belt is a strip of Chickamauga limestone forming a narrow valley. The Rockwood formation, the Chattanooga black shale and the Fort Payne chert next form a pair of ridges. Outside these ridges the Floyd shales and the lower portion of the Bangor limestone determine valleys; and finally are the opposing cliffs of Lookout sandstone. The order in which the formations occur is identical in passing either way from the central belt of dolomite. But the topography is not precisely symmetrical since the strips of each formation are narrower on the west side of the axis than on the east, for a given thickness of rocks occupies a narrower space at the surface with steep than with gentle dips, and so the want of symmetry in the fold produces a corresponding want of symmetry in the surface distribution of the several formations. It is found, however, at certain points, as at Sheffield Gap on the line of the Coosa and Tennessee railroad, that while this regular sequence holds for the eastern side of the valley it does not for the western. One or more of the formations disappear for a short distance so that the outcrops of the overlying and underlying formations come in contact. There is no invariable rule as to the order in which the formations disappear, though it is most common to find the dolomite encroaching upon the higher formations and successively overlapping them from the lowest up. First the valley of Chickamauga limestone disappears, the dolomite coming in contact with the Rockwood shale ridge. Next, the ridge disappears, then the valley back of it, and finally the dolomite is found thrust against the upturned edge of the Lookout sandstone. An inspection of the following sections will show the relation between the thrust fault and the successive disappearance at the surface of the several formations. Figure 10 is a section through the anticlinal, showing its normal form. In this the sequence of formations on either side of the axis is the same. Figure 11 represents the anticlinal fold at a point where the fault has begun and the thrust is sufficient to hide only a single formation. The dolomite rests upon the broken edges of the Chickamauga limestone and at the surface comes in contact with the next higher formation, the Rockwood shale. The next section, figure 12, shows the same fault at a point where it has attained its maximum displacement. The dolomite here overplaces and hides all the formations below the Lookout sandstone against the upturned edge of which it is seen to lie.

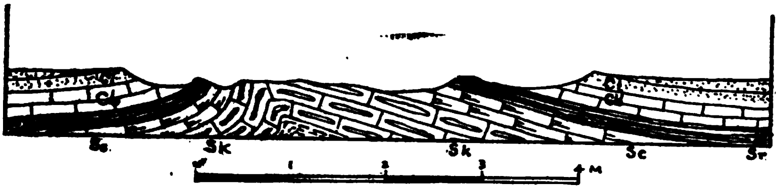

Figure 10. Section across Wills valley near Fort Payne; showing the *normal unsymmetrical anticlinal fold.*

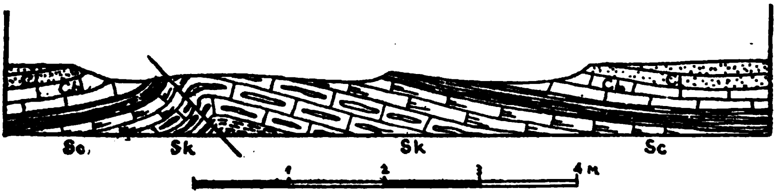

Figure 11. Section across Wills valley three miles north-east of Collinsville; showing a *thrust fault* by which the Chickamauga limestone Sc on the western side of the valley is concealed.

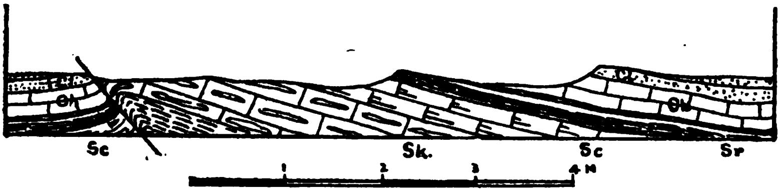

Figure 12. Section across Wills valley three miles south-west of Collinsville; showing a *thrust fault* by which all formations between the Knox dolomite Sk and the Lookout sandstone Cl on the western side of the valley are concealed.

Since the fault plane is not exactly parallel with the axis of the anticlinal its relation to the beds is variable and it may cut them so that the Chickamauga limestone or the Rockwood shale may be the formation which shall overlap the higher ones. Thus, at Rodentown, the Chickamauga is thrust over upon the Lookout sandstone, overlapping the Rockwood shale, the Fort Payne chert, and the Bangor limestone. And at Belcher Gap the Rockwood shale overlaps the Fort Payne chert and the greater part of the Bangor limestone.

An understanding of these faults is of the highest importance to the prospector since to them is due the occasional complete disappearance of the iron bearing Rockwood formation in this and similar valleys of northern Alabama. The faults which occur at intervals along the western side of Wills valley have most of the essential characteristic of the southern Appalachian thrust faults, but they are insignificant in extent and in the amount of displacement, compared with those further east.

Taylors Ridge Fault.—The synclinal of which Taylors ridge forms the western edge is cut off by a fault along nearly the whole of its eastern side. Portions of the eastern limb of the synclinal remain, but in these the rocks are vertical or slightly overturned. From Woods gap northward the fault is continuous, bringing the Cambrian at different points against each of the overlying formations up to the Carboniferous. Only the southern end of this fault is within the map area, but it extends toward the northeast entirely across Tennessee and well into Virginia, a total distance of about three hundred miles.

Rome Thrust Fault.—Another fault extends two hundred miles to the northeast, parallel with that above described. It enters the map area near its northeast corner, and follows along the east base of the Rocky Face and Chattoogata mountains, shearing off the eastern side of those synclinals and bringing the Cambrian against the Upper Silurian and Carboniferous rocks. A section, figure 13, through Chat-

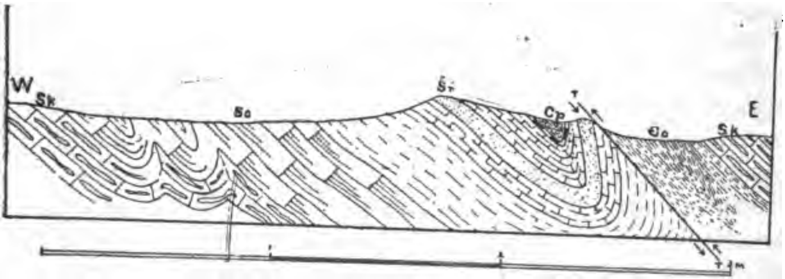

Figure 13. Section through Chattoogata mountain four miles south of Buzzard Roost gap; showing the position of the *Rome thrust fault* indicated by the line T T.

toogata mountain four miles south of Buzzard Roost gap, shows the nature of the fault at this point. While the hade of the fault as indicated in the section is hypothetical, being placed at 45°, there is a fair degree of probability that this represents its actual position. A consideration of the mechanism of the thrust fault indicates at least that this is the position of a plane on which there is the greatest liability for fracture to take place, and that the fault plane must have nearly the same dip as the strata in the unbroken limbs of adjoining anticlinals. Also, if the fault plane were vertical its trace upon the surface would not be influenced by elevations and depressions, but would be approximately straight. On the other hand, if the thrust plane approached the horizontal its outcrop at the surface would be rendered extremely devious by these surface inequalities. Hence the hade of a fault may be determined, within certain limits, by its line of outcrop when platted upon the map.

The fault above described as following the eastern base of Chattoogata mountain extends a long distance to the southwestward, but with a decided change in character which places it in the second group. In these the plane on which the motion took place approaches nearly or quite to the horizontal. This remarkable fault has already been somewhat fully described by the writer under the name of the "Rome thrust fault."*

From the southern end of Chattoogata mountain to Coosaville the stratigraphic displacement is sufficient to bring Cambrian in contact with Carboniferous rocks. The contact is marked by no topographic feauture and the discrimination of the two shale formations is at first difficult. Careful search, however, always reveals the presence of Cambrian fossils in the Coosa, while the presence of more or less carbonaceous matter serves to distinguish the Floyd shale. Occasional beds of highly fossiliferous limestone in the latter remove all doubt as to its Carboniferous age. The line of contact between the Coosa and Floyd shales is extremely irregular, but it has been traced with considerable care and accurately located at a large number of points. All along this irregular line the Floyd shale everywhere passes under the Coosa, so that the long arms of Coosa which extend westward from the main body of the formation undoubtedly rest upon the Floyd, and a consideration of the relation which they sustain to the structure of the underlying strata explains their peculiar distribution. The structure of the region lying immediately west of the fault line between Taylors ridge and the Oostanaula river has already been very briefly described. The strata have been thrown into a number of folds so as to form an irregular corrugated surface with a generel pitch toward the southeast. The anticlinal axes north of Armuchee creek, for a short distance at least, trend northwest and southeast while those to the south trend northeast and southwest. Among the anticlinals belonging to the northern group are Chattoogata mountain, Sugar ridge, East and West Horn mountains, and Johns mountain; the axes of which all pitch toward the southeast. In the southern group are Lavender mountain, Beech creek, and Horseleg mountain anticlinals, with axes pitching toward the northeast. Ridges are formed wherever these anticlinals bring hard beds, as the Fort Payne chert and Rockwood, above the level of the Coosa river, but where only the soft Floyd shales reach this level they are planed down to a smooth surface and give no indication by elevations of the folds which are present. Thus the Horseleg anticlinal brings the hard beds far enough above the river to produce a prominent ridge, while the Beech creek anticlinal lying to the west is not marked by any considerable surface elevation.

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*The overthrust Faults of the Southern Appalachians. Bull. Geol. Soc. Amer. Vol. II., 1891, p. 141.

Returning now to the distribution of the Coosa shales an inspection of the map shows that to the eastward of Lavender and Johns mountains each synclinal trough bears an arm of Coosa in its lowest part. Thus the narrow synclinal lying between the Horseleg and Beech creek anticlinals holds a long narrow strip of Coosa shales, while a broader belt occupies the synclinal between Beech creek and Lavender anticlinals. In short the distribution of the rocks over this considerable area suggests almost perfect stratigraphic conformity between middle Cambrian and middle Carboniferous, *the Cambrian being on top.* The accompanying section, figure 14, from Rome northwestward to Texas valley, will serve to show more fully the relations which the Cambrian and Carboniferous rocks bear to each other. Beginning with the Knox dolomite east of the city and passing toward the northwest the formations underlying the dolomite are passed, the Connasauga shale, Rome sandstone, and Coosa shale, all dipping to the southeastward. But after passing a narrow strip of Coosa the Floyd shale is found dipping also to the southeastward, apparently conformable with the Cambrian and Silurian formations above. On the western side of the Horseleg mountain anticlinal the Floyd dips toward the northwest passing under a narrow area of Coosa which occupies the synclinal trough between Horseleg mountain and Beech creek anticlinals. Beyond the latter the Floyd dips again toward the northwest passing beneath a second and broader arm of Coosa which lies in the synclinal between the Beech creek and Lavender mountain anticlinals.

The present relation of these formations is manifestly the result of a fault by which the older beds were thrust over from the east upon the younger on a plane which coincides approximately with the bedding. This thrust plane is represented in the section, figure 14, by the heavy broken line TT. It is not a plane surface as it probably was originally, but since the faulting it has been thrown into a series of gentle folds. The greater part of the overthrust strata have been removed by erosion which has reduced the surface of both Cambrian and Carboniferous shales to the base level of Coosa river. Their line of contract as shown on the map is therefore the intersection of an undulating thrust plane with the horizontal base level plane. Wherever the folding subsequent to the displacement has brought the thrust plane below the present base level, that is in the synclinals, there

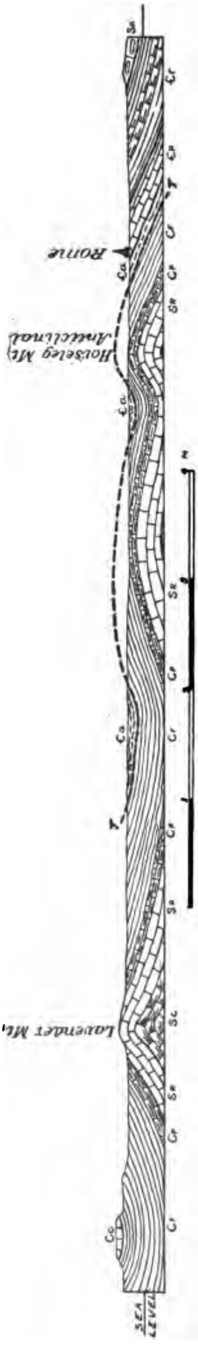

Figure 14. Section from Rome north-west to Texas valley; showing the relation of the Cambrian shales Ca to the underlying Carboniferous shales Cf. The line T T indicates the position of the *Rome thrust fault* plane on which the older rocks have been thrust over from the eastward upon the younger.

the overthrust rocks remain, while those at higher levels upon the anticlinals have been entirely removed. If the surface of the Coosa valley were lowered only a few hundred feet it is probable that all the Cambrian shales would be removed from the shallow synclinals in which they lie.

The distance through which the older strata have been moved westward over the younger by this thrust fault is between four and five miles and there is reason to believe that the Cambrian rocks once extended several miles further westward than they are at present found.

West of Coosaville the fault continues to Round mountain with much the same character except that the northwestward prolongations of the Cambrian shale are not so extensive as those above described. The reason for this is that the axes of the folds north of the fault pitch toward the southeast very rapidly and hence do not afford extended shallow synclinals in which the Coosa shales might remain protected from erosion.

Between Coosaville and the Alabama line one small area of Coosa shale occurs wholly isolated from the main body and lying upon beds which occur near the top of the Knox dolomite. In this case it is evident that the connecting shales have been removed by erosion leaving this small area protected by its position in a basin of Kxox dolomite below the level of Coosa river.

From Round mountain southwest to Gadsden the fault line follows approximately parallel with the eastern edge of Lookout mountain. Since the intersection of the thrust plane with the present land surface is nearly a straight line, a comparatively steep hade for this portion of the fault might be inferred, but that it is even here a broad overthrust is shown by the presence, five miles east of Gadsden, of a small area of Knox dolomite. This isolated area is wholly surrounded by Cambrian shale which appears to have been thrust over the dolomite from the eastward. Afterwards the overthrust Coosa was eroded through at this point down to the rocks lying below the thrust plane. The continuation of the Rome fault southward beyond Gadsden has not been studied in detail. It is probably replaced by several faults of the east Tennessee type which shear off the eastern sides of the Cahaba and Coosa Coal fields as shown by Squire and McCalley.

With the exception of the Rome thrust fault all that have thus far been considered are in a general way parallel to the strike of the rocks. The faults with steep hade seldom cut across the beds, or when they do it is only for a short distance and at a very slight angle with the strike. They may be termed strike faults. This parallelism between the lines of fracture and the anticlinal axes permits the former to extend for long distances as above-described, with a constant relation to the same folds.

Transverse Faults.—An inspection of the map will show that on a line between Rome and Atalla there is a sudden transition in structure. The structural axes, which on the north of this line trend north 10° to 30° east, are abruptly terminated by an axis running nearly east and west. This sudden change in direction of strike gives rise along this line to a series of transverse faults as rare as the peculiar conditions by which they are produced. The three faults which come under this class are those terminating the Gaylors ridge, Dirt Seller mountain and Lookout mountain synclinals. In every case the northern ends are strike faults of greater or less extent along the east side of the synclinals. Approaching the Coosa valley which marks the east and west axis above mentioned, they abruptly change their course, swinging sharply around to the west. After crossing the synclinal they die out in the anticlinal beyond. The faults terminating both Gaylors and Dirt Seller synclinals pass beneath the plane of the Rome thrust for short distances. It seems probable that in this region considerable folding, faulting and erosion was accomplished before this thrust and that the present complicated relations of the strata were produced by at least two periods of intense compression separated by a period of comparative rest.

The most remarkable of these transvere faults is the one which terminates the Lookout mountain synclinal. Between Gadsden and Atalla the east and west axis turns sharply toward the southwest, continuing down Canoe Creek valley. It thus results that the Canoe creek anticlinal and the Lookout synclinal come together, end to end. Such a relation between a downward bending trough and an upward bending arch necessitates an enormous shear where the two come together. And this is exactly what has taken place along the line between Gadsden and Atalla. The friction of the strata in slipping past each other has bent their edges at an abrupt angle near the fault plane; the Lookout sandstone on the side which went down is turned up into a vertical position and forms a distinct ridge along the northern side of the fault line. In contact with this on the south are the downward flexed Coosa shales. This bending of the strata by the drag of the fault is represented in the section, figure 15, which crosses the fault at right angles.

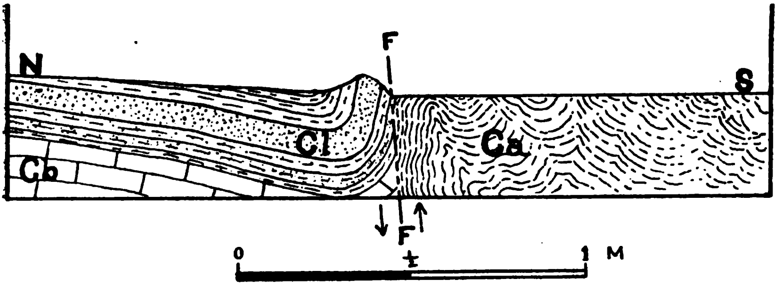

Figure 15. Section north and south along Black creek; showing the position of the *transverse Gadsden-Atalla fault.*

The slipping plane of the Gadsden-Atalla fault is probably very nearly vertical, or it may dip under the depressed beds. Being transverse to the line of compression this would not be improbable. It might, therefore, be classed as a normal fault, in accordance with the definition already given, except for its very intimate relations with the thrust faults of the region.

Faults of the Weisner Region.—As already stated, there is a small area lying between Weisner and Indian mountains which has a peculiar and extremely complicated geologic structure. It would require a detailed map of this region on a large scale with numerous sections to adequately represent the structure but this detailed statement is not practicable in the present report. Only the general conclusions can be given here.

Weisner and Indian mountains are monoclinal ridges formed by heavy beds of Weisner quartzite which occur interbedded with the Rome sandstone and shales. They present toward the northwest steep and rugged faces formed by the broken edges of the quartzite beds while the southeastern sides have a more gentle slope with the dip of the strata. The region between these two main ridges is occupied by a number of subordinate ridges somewhat irregular in their arrangement but in general parallel among themselves and extending in a direction more nearly north and south than the main ridges. These subordinate ridges are composed for the most part of Knox dolomite and Rockwood sandstone, while the intervening valleys are underlain by Chickamauga limestone and shale.

A belt of Knox dolomite extends along the northwestern side of the complicated area in a northeast and southwest direction parallel with Weisner and Indian mountains. This belt is composed of a number of short ridges extending nearly north and south and slightly overlapping; that is, each ridge extends a little further north than the next one to the westward. A similar belt of Rockwood sandstone ridges lies to the southeast parallel with the dolomite belt though it is not so continuous or regular as the latter. The region has aparently passed through the structural stage in which the strata occupy simple folds or even folds accompanied by faults parallel with the axes, though some traces of the folds still remain. Thus the Knox dolomite belt above discribed was aparently the northwestern edge of a synclinal which occupied the region between Weisner and Indian mountains. The later formations which mark the axis of the synclinal form an irregular belt passing through Rock Run. This synclinal has been almost wholly obliterated by a series of faults which extend nearly north and south, cutting across its axis at an angle of about 45°. By these faults the strata have been broken up into a number of blocks and the blocks of strata have been slid over upon one another so that they now overlap like the shingles of a roof. Each of the subordinate ridges which make up the belt of Knox dolomite, is composed of a block of strata separated from adjacent ridges by faults. The same is true of the sandstone ridges which form the corresponding belt toward the southeast.

What the conditions were which produced this peculiar structure can only be conjectured, but they seem in some way connected with the transverse faults on the opposite side of Coosa valley. Both sets of phenomena at least appear to be due to the action of similar forces, and there are indications that in both cases the faulting took place after the original folds had suffered considerable erosion.

The faults, by means of which the blocks of strata are shingled up one upon another, have been traced only to the edge of the dolomite belt but it is altogether probable that they extend much further into the Cambrian area of Coosa valley and additional study may make it possible to locate them.

The extensive deposits of limonite iron ores which occur in this region are closely connected with these faults. The fracturing of the rocks appears to have afforded an opportunity for the percolation of waters bearing iron in solution so that the iron originally disseminated through the surrounding rocks has been leached out and redeposited along these fault lines.

The difficulties of determining the structure of this region or even of accurately mapping the surface outcrops of the various formations are greatly increased by the decay and deep disintegration of the rocks brought about by the faulting. Thus the chert of the Knox dolomite, which is elsewhere an unfailing index to that formation, frequently disappears in this intensely faulted region. Chert or flint is simply silica in an amorphous or uncrystalline condition. Where it has been subjected to great pressure, with the increased temperature which must have accompanied so extensive faulting, an internal re-arrangement appears to have taken place in the chert by which its character is wholly changed and it becomes an incoherent white substance closely resembling chalk. This chalk-like material is often found associated with the limonite iron ores, and it sometimes retains the external form of chert nodules. It of course offers little resistence to weathering and affords no indication on the surface of the underlying formation so that the outcrops of all the Silurian formations are frequently deeply covered with a uniform deposit of red clay soil.

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EXPLANATION OF PLATE.

Plate I. Sketch map of a portion of Lookout mountain, Wills valley and Sand mountain; showing various stages in the development of the present drainage system and topography.

Fig. 1. Showing the undulating surface which determined the initial position of the streams. B B and T T flow in synclinal troughs and receive side streams l, l, l and s, s, s from the intervening anticlinal ridge.

Fig. 2. Showing a stage in the development when the side streams l, l, l and s, s, s have cut through the hard surface rocks to soft beds beneath and lateral valleys, w, w', etc., are being formed parallel with the anticlinal axis.

Fig. 3. Showing a further stage in the development when the lateral stream, w, has cut through the intervening divides and diverted the drainage of l' and l". A second series of lateral streams, W, etc., is being developed along the anticlinal parallel with the first series, W W, etc. The upper portion of the synclinal stream, B B, has been diverted by a side stream, R R.

Fig. 4. Showing the present drainage system and topography. Both lateral streams, w and W, have continued to encroach upon the basins of those adjacent. w resulting in the present Little Wills creek and W in Big Wills creek. The latter now occupies the axis of the anticlinal throughout its whole length and has become the dominant stream of the system under consideration. The stream B B has been further robbed of portions of its drainage basin by streams flowing eastward to the Coosa. The synclinal stream T T has been tapped at various points by streams flowing westward into the Tennessee and the drainage thus diverted from its original course toward the south.

Plate 1

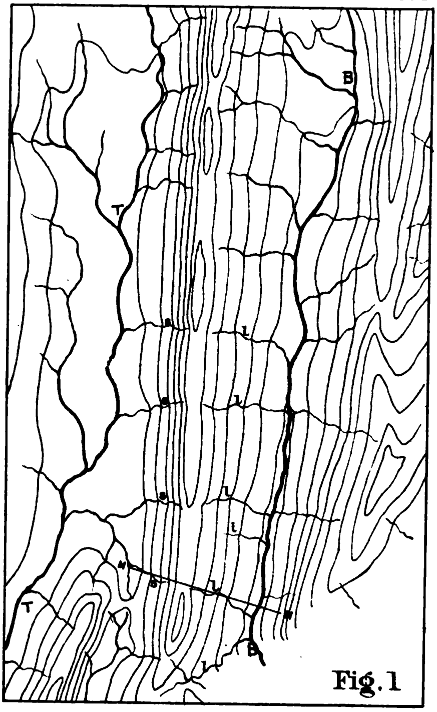

Fig. 1

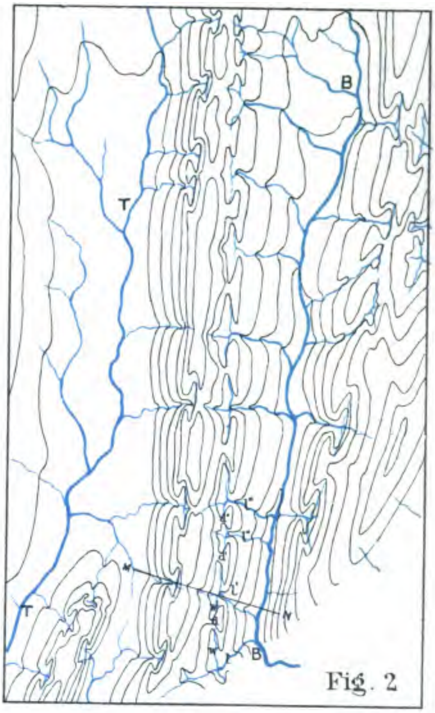

Fig. 2

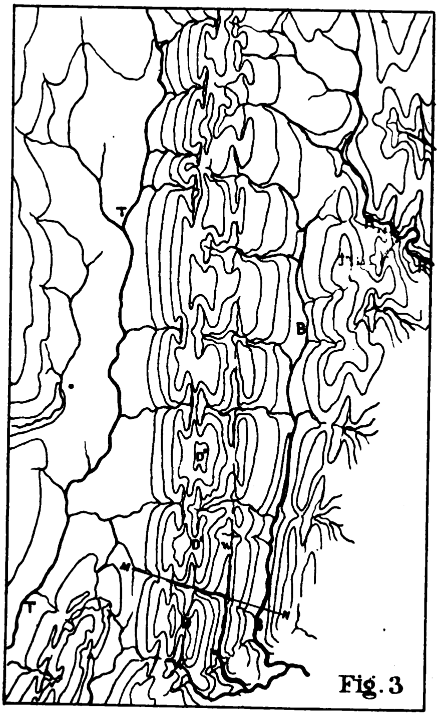

Fig. 3

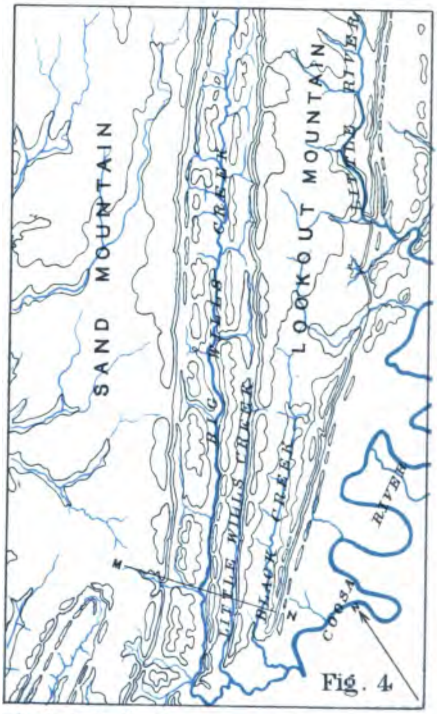

Fig. 4

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